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ABSTRACT

The materials included in "Automotive Computer Units" represent a unit of instruction to acquaint auto mechanics at all skill levels with the use of computers in today's automobiles. The unit is designed for use in full-time secondary and postsecondary classes and part-time adult classes. It may be adapted to open-entry, open-exit programs for short-term courses or as part of a more indepth course. This unit is not specifically designed to be presented in one lesson or class period of instruction. The unit consists of eight basic components: performance objectives, teacher activities, supplements (transparencies that present new information or reinforce information), information sheets (content essential for meeting the cognitive objectives), assignment sheets (applications of knowledge that is a prerequisite to skill development), job sheets (procedures to complete a manipulative or psychomotor skill), tests, and test and assignment sheet answers. The material in the unit is intended to enable the student to describe the functions of automotive computer components and to diagnose computer-related malfunctions. (YLB)

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Automotive Computer Units

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FOREWORD

In Oklahoma, vocational educators have a basic belief that quality vocational programs require the use of sound instructional materials. It is this belief that prompted the Oklahoma State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center to develop a curriculum tailored to provide high-quality and uniform training materials for the automotive mechanics trades. The series includes two volumes to introduce students to the principles of auto mechanics, including system operation, repair, and servicing. Additionally, units of instruction have been developed for specialty areas such as electronic ignition and turbocharger systems. "Automotive Computer Units" is yet another step toward the goal of providing current, technically accurate instructional materials for this trade.

Industry representatives, classroom teachers, and technical specialists collaborated closely to produce materials that will provide each student with information and practical learning experiences directly applicable to the auto mechanics trade. Whether the students are just entering the trade, seasoned mechanics upgrading skills, or skilled mechanics reviewing procedures and using these materials as reference, they can appreciate the expertise of all those who created "Automotive Computer Units."

The information in "Automotive Computer Units" should be adapted, personalized, and localized so that this publication will become a vital part of the teaching/learning process. It is our sincere hope that "Automotive Computer Units" and the other manuals in this series will contribute to the development of a competent, safety-conscious workforce in the auto mechanics trade.

Francis Tuttle, Director
Oklahoma State Department of
Vocational and Technical Education

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PREFACE

The purpose of "Automotive Computer Units" is to acquaint auto mechanics at all skill levels with the use of computers in today's automobiles. Many workers in various trades seem to be overwhelmed by the rapid advances of modern technology. There is often a tendency to suspect the unknown, and manufacturers' representatives have heard a great many complaints from customers who blame their cars' computers for every malfunction imaginable, from faulty air conditioners to inoperative dome lights. The use of computers is just another advance like electric starters and power steering that provides convenience but requires some getting used to. This volume is designed to take away some of the mystery surrounding automotive computers.

This unit has been designed so that it may be used in full-time secondary and post-secondary classes as well as part-time adult classes. It can also be adapted to open-entry, open-exit programs for short-term courses or as part of a more in-depth course. Every attempt has been made to make the content general enough that wide application is possible, yet specific enough that it serves as a practical teaching tool.

We encourage instructors to take full advantage of the flexibility designed into these materials. By supplementing, personalizing, and localizing this unit, the instructor will be able to provide a good introduction to automotive computers and to help students—both beginners and skilled mechanics—to advance toward a successful career in auto mechanics.

Bob Patton, Coordinator, Curriculum
and Instructional Materials Center

Jerry Kenney, Auto Mechanics Instructor
Great Plains AVTS

ACKNOWLEDGEMENTS

I am indeed grateful for the generous contributions of time, expertise, and support that I received from the automotive computer review committee and from the schools and industries they represent. "Automotive Computer Units" could not have been developed without the cooperative efforts of the following:

Ivan Armstrong, State Department of Vocational and Technical Education

Jim Creitz, Auto Mechanics Instructor Tulsa County AVTS, Broken Arrow Campus

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Bill Hill, State Department of Vocational and Technical Education

Bob Janda, General Motors Training Center, Oklahoma City

Zollie Johnson, Auto Mechanics Instructor, Foster Estes AVTS

Bob Petkoff, Ford Motor Company Training Division, Oklahoma City

Ray Schoonmaker, Auto Mechanics Instructor, Northwest AVTS

James Sharpton, State Department of Vocational and Technical Education

Bob Janda and Bob Petkoff deserve special recognition for their tireless efforts in this project. Both men made room in extremely busy schedules to offer guidance in the course of developing this material and to answer the countless questions that arose as I wrote the unit. Their encouragement and the resources they provided set the direction taken in this project and made the final product possible.

I sincerely appreciate the excellent assistance and the permission to use copyrighted materials granted by General Motors Corporation and Ford Motor Company. The illustrations provided by both companies greatly enhance the unit and its instructional usefulness.

When I suggested the project to the Curriculum and Instructional Materials Center, I could not have asked for more encouragement or a greater commitment of resources. I am grateful to Bob Patton for his insight in seeing the importance of this project and his willingness to make room for it in an already crowded list of development priorities. This sense of commitment was equally evident in the members of the CIMC development staff under Joyce Sawatzky. I owe a special debt of gratitude to Robert Hilley, who served as project coordinator for "Automotive Computer Units" and whose concern for high-quality, effective instructional materials did much to shape the revision of my first draft. Further refinement of the content and format of this publication resulted from the caring attention of the CIMC editing staff under the supervision of Terri Barnes. Their help and guidance, their attention to detail, and their concern for a quality product were invaluable in completing this project. My gratitude goes to Sue Buck, Sue Feasley, Terra McCluskey, Susan Walker, and Jerry Weir.

Working on this project has given me a deep appreciation for the variety of skills and the number of hours required just to produce a single unit of instruction in print. The State Department of Vocational and Technical Education Graphics Division provided the services necessary for actual physical production of this manual. The credit for typesetting the several drafts, including the final copy, goes to the staff of the Communications Center under the supervision of Jenny Fowler. Those involved in typesetting this unit include Dona Landreth, Allison McLaughlin, and Gari Sha Robinson. Nancy Hilley and Dana Welborne did the additional art work and layout required in the Art Department, managed by Carrie Williams. Finally, the Print Shop, under Noel Wilcoxson, produced the quality appearance of the published material.

My sincere thanks to all involved.

Jerry Kenney

USE OF THIS PUBLICATION

Instructional Unit

The materials included in "Automotive Computer Units" represent a unit of instruction. A standard format was established in 1970 for development of instructional materials for all Oklahoma vocational teachers. This format includes eight basic components that form a unit of instruction: performance objectives, suggested activities for the instructor, information sheets, assignment sheets, job sheets, supplements, test, and answers to test and assignment sheets.

All of the unit components "zero in" on measurable and observable learning outcomes. Instructors are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

This unit of instruction is not specifically designed to be presented in one lesson or class period of instruction. Careful study of the unit content by the instructor will help him or her determine the following

A. Amount of material that can be covered in each class period
B. Skills that must be demonstrated
    1. Supplies and equipment needed
    2. Amount of practice needed
    3. Amount of class time needed for demonstrations
C. Supplementary materials, such as pamphlets and filmstrips, that must be ordered
D. Resource people who must be contacted

Performance Objectives (white pages)

This unit of instruction is based on the performance needed for successful employment in an occupational area. Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction, and specific objectives, stating the performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching/learning process, it is important that teachers and students have a common understanding of the intent of the objectives. Following is a list of performance terms, their meanings, and behavioral synonyms that may have been used in this material.

A. Name — The individual supplies a name for objects, events, or people

    Behavioral synonyms: Label, list, letter, record, reiterate, repeat, write

B. Identify — The individual selects a named, described, or pictured object by pointing to it, touching it, picking it up, or selecting it

    Behavioral synonyms: Select, mark, match, choose, judge

C. State a rule — The individual communicates a relationship or principle that could be used to solve problems or perform a task

D. Apply a rule — The individual supplies an answer to a problem by using a stated relationship or principle

Behavioral synonyms: Solve, calculate

E. Describe — The individual relates sufficient characteristics or properties of an object or event so that a second individual will be able to state what is being discussed

Behavioral synonyms: Define, discuss, interpret, recite, tell how, tell what happens when

F. Distinguish — The individual selects an object or event from two or more that are easily confused

Behavioral synonyms: Discriminate, differentiate

G. Order — The individual arranges three or more objects or events in a sequence based on a stated property

Behavioral synonyms: Arrange, sequence, list in order, classify, divide, isolate, sort

H. Construct — The individual makes a physical object, a verbal statement, or a drawing

(NOTE: *Construct* is used when the finished product or result is important.)

Behavioral synonyms: Draw, make, build, design, formulate, reproduce, transcribe, convert, put together, compile

I. Demonstrate — The individual performs several operations necessary to carry out a specified process

(NOTE: *Demonstrate* is used when it is desirable to watch the student perform a task, one of the highest levels of student performance.)

Behavioral synonyms: Show your work, show procedure, perform an experiment, perform the steps, operate, remove, replace, turn off/on, (dis)assemble, (dis)connect

The objectives should be provided for students and stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for the unit. The objectives can also help determine teaching strategies and instructional methods. Prepare to teach the unit by deciding how each objective can best be taught.

The objective sheet may also be used as a quick pretest to determine prior knowledge of students and to determine whether further study or activities are necessary. Instructors should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When changes in objectives are made, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion test items.

Suggested Activities (pink pages)

This component is included only in instructor material. The suggested activities page assists instructors during the preparation stage of the teaching/learning process by providing suggestions for delivery and/or presentation during the instructional process. Read the suggested activities before teaching the unit so that supplemental materials can be obtained, audio-visual materials prepared, and outside resources contacted.

The references that are listed are ones used in the development of the unit. They should be used by the instructor to supplement his or her knowledge of the subject area or to help students with particular interests or occupational objectives in the area covered.

Supplements (pink pages)

Supplements provide information in a special way. Supplements may present new information, or they may reinforce information presented in the information sheet. They are particularly effective when identification is necessary. Transparencies direct the class's attention to the topic of discussion. Make transparencies of the supplements and place them in the notebook where they will be immediately available for use. The instructor may also choose to copy some of the supplements to distribute to the students.

Information Sheet (green pages)

The information sheet provides "must know" content essential for meeting the cognitive (knowledge level) objectives of the unit. The information is written in a topical outline form and is keyed to the specific objectives.

Instructors will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. The information sheet may also be used for coordination activities and advisory committees.

Students should read the information sheet before the information is discussed in class. Space is provided in margins for students and instructors to add notes that supplement, localize, personalize, or provide motivation for each unit.

Assignment Sheets (brown pages)

Assignment sheets give students a chance at problem solving, self-assessment, and/or practical experience with the information. They assist students in the application of knowledges that are necessary prerequisites to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided when appropriate and can be used by the student and/or instructor for checking student progress.

Job Sheets (blue pages)

Job sheets are another important segment of this unit of instruction. The job sheets provide a list of equipment, tools, and materials needed to complete a manipulative or psychomotor skill. They describe a step-by-step procedure needed to complete each task or job. Diagrams, photographs, and illustrations are provided to assist students in achieving the skill.

Instructor should demonstrate to students the procedures outlined in each job sheet. Furthermore, the instructor needs to localize the job sheet according to the equipment and supplies available in the local shop situation. Job sheets also furnish potential employers with a picture of the skills being taught and the performances they might reasonably expect from a person who has had this vocational instruction.

Test (yellow pages)

This component provides criterion-referenced evaluation of every objective listed in the unit of instruction. It is crucial to note that both paper/pencil and performance objectives must be evaluated.

The test may be written or oral. It is recommended that the test be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. If objectives have been added, deleted, or modified, be sure to make the changes on the test.

The acceptable response of 85 percent on the unit test may be raised or lowered to fit the students' ability levels. The percentage applies to the overall score, not to each question. The final unit grade should be obtained by using the paper/pencil score along with evaluations of student demonstrations of the desired skills.

Answers to Test and Assignment Sheets (pink pages)

These components are designed to assist the instructor in evaluation of student performances.

Page Numbering

Each publication from the Curriculum and Instructional Materials Center is assigned a specific abbreviation. For example, "Automotive Computer Units" has been abbreviated ACU. An example of a page number is ACU-1. Since CIMC publications are loose leaf, this system of page numbering was adopted so that pages from different manuals would not get mixed up.

Methods of Disseminating Material

Material may be given out a unit or page at a time to keep the material before the student always new. Some instructors ask students to furnish a three-ring binder for the unit. This is convenient for taking the materials home to study.

For best results, provide student materials for each student. Student materials contain everything but the test answers, answers to assignment sheet, and suggested activities. The test is located at the back of student material and should be removed and stored until needed. Students should be allowed to take their materials home at the end of the course.

Teaching Methods

It is a challenge to keep students motivated. Supplement the objectives by providing the "why," personal experiences, and current information. Prepare for the unit by deciding how each objective can best be taught. Allow students to become involved in preparing and planning.

CORRECTIONS AND SUGGESTIONS

The Curriculum and Instructional Materials Center wants to provide vocational instructors and students with materials that are accurate and effective. Although the Center strives to maintain the highest standards of development and production, oversights occasionally do occur. If you find any errors in this or other CIMC publications, or have suggestions for improving their usefulness in vocational programs, please notify the CIMC staff. One easy way of pointing out errors is to make a photocopy of the affected page and to indicate the correction on the copy. You can then mail the information to the CIMC, where it will be used to correct the publication before the materials are reprinted.

To ensure that the material is updated on a timely basis, it is important that you notify the Center of necessary corrections as soon as possible after discovering the error. Do not assume that someone else will notice the error and inform the CIMC; other users may be making the same assumption. Please send corrections and recommendations for improving this publication to the following address:

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AUTOMOTIVE COMPUTER UNITS
AUTO MECHANICS SUPPLEMENT

UNIT OBJECTIVE

After completing this unit, the student should be able to describe the functions of automotive computer components and be able to diagnose computer-related malfunctions. The student will show this knowledge by completing assignment sheet, job sheets, and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match to their correct definitions terms associated with automotive computers.
2. State the purpose of automotive computer systems.
3. List major functions of automotive computer systems.
4. Select from a list correct functions and operations of major sensor components in an automotive computer system.
5. List typical locations of automotive computer system sensor components.
6. Match automotive computer system actuator components to their correct functions.
7. Select from a list characteristics of a three-stage catalytic converter.
8. State preliminary steps in servicing a vehicle with an automatic computer system.
9. Discuss methods of performing a quick test of the automotive computer system.
10. State guidelines for performing a pinpoint test of the automotive computer system.
11. Match automotive computer system test equipment to their correct uses.
12. Label types of electrical connectors used in automotive computer systems.
13. Select from a list guidelines for splicing conductors in automotive computer systems.
14. Use service manual excerpts to determine procedures in response to automotive computer trouble codes.

OBJECTIVE SHEET

15. Demonstrate the ability to

    a. Perform preliminary checks and inspections on non-computer-related components.

    b. Determine stored computer codes, using the "check engine" light method.

    c. Use a digital voltohmmeter.

    d. Properly splice conductors used in computer-controlled components.

AUTOMOTIVE COMPUTER UNITS
AUTO MECHANICS SUPPLEMENT

SUGGESTED ACTIVITIES

I. Unit contents

A. Objective sheet

B. Suggested activities

C. Supplements

1. Supplement #1 — Everyday Computers
2. Supplement #2 — Automotive Computer Terminology
3. Supplement #3 — Automotive Computer Terminology (Continued)
4. Supplement #4 — Automotive Computer Functions
5. Supplement #5 — Oxygen Sensor
6. Supplement #6 — Oxygen Sensors
7. Supplement #7 — Engine Coolant Temperature Sensors
8. Supplement #8 — Pressure Sensors
9. Supplement #9 — Pressure Sensor Operation
10. Supplement #10 — Throttle Position Sensor
11. Supplement #11 — Vehicle Speed Sensors
12. Supplement #12 — Vehicle Speed Sensors (Continued)
13. Supplement #13 — Vehicle Speed Sensors (Continued)
14. Supplement #14 — Knock Sensors
15. Supplement #15 — Typical Sensor Locations
16. Supplement #16 — Actuator Response Categories
17. Supplement #17 — Actuator Response Categories (Continued)
18. Supplement #18 — Actuator Response Categories (Continued)
19. Supplement #19 — Carburetor Fuel Controls

SUGGESTED ACTIVITIES

20. Supplement #20 — Carburetor Fuel Controls (Continued)
21. Supplement #21 — Fuel Injection Fuel Controls
22. Supplement #22 — Ignition Timing Controls
23. Supplement #23 — Engine Idle Speed Controls
24. Supplement #24 — Exhaust Gas Recirculation (EGR)
25. Supplement #25 — Exhaust Gas Recirculation (EGR) (Continued)
26. Supplement #26 — Exhaust Manifold Heat Control
27. Supplement #27 — Exhaust Manifold Heat Control (Continued)
28. Supplement #28 — Evaporative Gas Canister Purge
29. Supplement #29 — Evaporative Gas Canister Purge (Continued)
30. Supplement #30 — Air Management (GM)
31. Supplement #31 — Air Management (Ford)
32. Supplement #32 — Air Management Paths
33. Supplement #33 — Air Management Paths (Continued)
34. Supplement #34 — Three-Stage Catalytic Converter
35. Supplement #35 — Noncomputer Problems
36. Supplement #36 — "Check Engine" Light
37. Supplement #37 — Diagnostic Circuit Check
38. Supplement #38 — Trouble Code Identification (GM)
39. Supplement #39 — Self-Test Automatic Readout (STAR) Display and Hookup
40. Supplement #40 — Self-Test Automatic Readout (STAR) Display and Hookup (Continued)
41. Supplement #41 — Jumper and Voltmeter Hookup and Reading
42. Supplement #42 — Jumper and Voltmeter Hookup and Reading (Continued)

SUGGESTED ACTIVITIES

43. Supplement #43 — Vacuum Diagram (1983 Ford)

44. Supplement #44 — Quick Test Chart (GM)

45. Supplement #45 — Quick Test Chart (Ford)

46. Supplement #46 — Engine Coolant Temperature Pinpoint Test (Ford)

47. Supplement #47 — Engine Coolant Temperature Pinpoint Test (Ford) (Continued)

48. Supplement #48 — Special Test Equipment

49. Supplement #49 — Special Test Equipment (Continued)

50. Supplement #50 — Electrical Connectors

51. Supplement #51 — Electrical Connectors (Continued)

52. Supplement #52 — Weather-Pack Terminal

53. Supplement #53 — Wire Splicing

54. Supplement #54 — Wire Splicing (Continued)

D. Information sheet

E. Assignment Sheet #1 — Use Service Manual Excerpts to Determine Procedures in Response to Automotive Computer Trouble Codes

F. Answers to assignment sheet

G. Job sheets

1. Job Sheet #1 — Perform Preliminary Checks and Inspections on Non-Computer-Related Components

2. Job Sheet #2 — Determine Stored Computer Codes, Using the "Check Engine" Light Method

3. Job Sheet #3 — Use a Digital Voltohmmeter

4. Job Sheet #4 — Properly Splice Conductors Used in Computer-Controlled Components

H. Test

I. Answers to test

SUGGESTED ACTIVITIES

II. Instructor's guide

A. Order materials to supplement unit.

(NOTE: Teaching this unit requires the use of manufacturers' charts for diagnosing computer trouble codes. In addition to the diagnostic manuals, the instructor may wish to use other materials listed in the following reference section. These materials are available from the respective manufacturers.)

B. Modify unit for use of available materials.

C. Make transparencies or copies of supplements as appropriate.

D. Provide students with objective sheet.

E. Introduce unit.

1. Explain that the use of computers in vehicles has increased greatly and will continue to increase, thus making it critically important that trained technicians be available to maintain these vehicles.

2. Dispel any fears that students may have about their ability to work on automotive computers by explaining that they operate computers daily and that normal service work requires only that they be able to operate the automotive computer.

EXAMPLES: Use a pocket calculator and Supplement #1 to demonstrate that a computer is simply a device that receives inputs (numbers and operations punched in on the calculator buttons), processes the information, and produces an output (the displayed answer on the calculator).

Ask students to discuss the basics of computer operations by talking about other everyday examples of the input-processing-output sequence, such as automatic bank tellers and video games.

F. Discuss unit and specific objectives.

G. Provide students with information and assignment sheets.

H. Discuss information sheet.

1. Discuss Information Sheet, Section I, explaining to students that a number of new terms will be used in the unit and in the manufacturers' computer systems manuals. Also explain that different manufacturers use different terms for the same or similar components; use Supplements #2 and #3 to show examples of some of the terms.

(NOTE: In this unit, generic names are used for most components, and the more common trade names are given in notes.)

SUGGESTED ACTIVITIES

2. Discuss the purposes of automotive computers outlined in Information Sheet, Section II by relating how the control of fuel-air mixtures, spark timing, and coolant temperature involves the input-processing-output sequence.

3. Use Supplement #4 to discuss the three major functions of automotive computers outlined in Information Sheet, Section III and to introduce Sections IV and V.

4. Use Supplements #5 through #14 to discuss the various sensor components outlined in Information Sheet, Section IV. Also use actual components if available. Emphasize that other sensors are used in automotive computer systems, but that those illustrated are the most common. Supplement your instruction with the following information if desired.

   a. Oxygen sensor — Also called *exhaust gas oxygen (EGO) sensor* or *0_2 sensor*

      1) Does not operate until exhaust temperature reaches 600°F (316°C)

      2) Needs 14.7:1 ratio of oxygen in ambient air to oxygen in exhaust for maximum emission control

         (NOTE: It may be helpful for the student to think in terms of using 15 gallons of air for each gallon of gasoline used.)

      3) Requires a digital voltohmmeter with at least a 10-megohm impedance for testing to avoid damaging sensor

   b. Engine coolant temperature sensor — Also called *ECT sensor* or *coolant temperature sensor*

      (NOTE: Emphasize the importance of the ECT sensor because of its influences on other sensors.)

      1) Provides input to computer for other sensors (i.e., oxygen sensor) to make necessary adjustments for engine temperature, such as that required for cold engine starts

      2) Uses a thermistor that typically controls a 5-volt circuit with a range of 100,000 ohms at −40°F (−40°C) to 77 ohms at 266°F (130°C)

SUGGESTED ACTIVITIES

c. Pressure sensors — Also indicated as *BP* or *BARO* for barometric pressure sensors; *MAP* for manifold absolute pressure sensors; and *VAC, vacuum,* or *B/MAP* sensors for combination units

(NOTE: Use Supplements #8 and #9 to discuss diaphragm operation.)

1) The greater the differential pressure, the stronger the electrical output

2) Increased intake manifold pressure requires a higher fuel content in the air-fuel mixture

3) Radio and electrical signals may interfere with operation

d. Throttle position sensor — Also called *TP sensor* or *TPS*

1) Uses voltage variation to indicate throttle position

2) Provides driver-demand input to computer

3) Is roughly equivalent in function to carburetor-ported vacuum in noncomputerized systems

e. Engine rpm sensor — Also referred to as *crankshaft position (CP) sensor* or *profile ignition pickup (PIP)*

1) Uses a magnetic bar in harmonic balancer to produce input signals

2) Is most common today in the high-energy ignition system

f. Vehicle speed sensor — Also referred to as *VSS*; is sensitive to radio and electrical interference

g. Knock sensor — Also called a *detonation sensor*

5. Use Supplement #15 to discuss sensor locations outlined in Information Sheet, Section V. Point out those sensors that may have more than one location.

6. Discuss Information Sheet, Section VI, emphasizing that the automotive computer makes actuator adjustments based on the combined readings of the different sensors. The air-fuel mixture, for example, is adjusted based on input signals from the oxygen sensor, the engine coolant temperature sensor, pressure sensors, and the throttle position sensor.

a. Use Supplements #16 through #18 to illustrate actuator adjustments.

b. Use Supplements #19 through #21 to show types of fuel supply systems.

SUGGESTED ACTIVITIES

c. Use Supplement #22 to show ignition timing controls.

d. Use Supplement #23 to discuss engine idle speed controls. Mention other conditions (i.e., high engine temperature, low battery voltage) that might be monitored to regulate engine idle speed. Inform students that adjustment of the neutral safety switch affects operation of some engine idle speed controls.

e. Use Supplements #24 and #25 to discuss exhaust gas recirculation. Emphasize that EGR controls have been in use for several years, but that computerization allows more accurate regulation.

f. Use Supplements #26 and #27 to discuss exhaust manifold heat control. Emphasize that such systems have been in use for years but are now computerized.

g. Use Supplements #28 and #29 to discuss evaporative gas canister purge. Again point out that this concept has been used for years but has been improved through computerization.

h. Use Supplements #30 and #31 to discuss air supply management systems. Point out that this is yet another system that has been modernized through the use of computer control. Discuss the use of other diverter valves. Use Supplements #32 and #33 to discuss the different diverter paths. Use Supplement #34 to introduce Information Sheet, Section VII, and to illustrate the use of diverter valves to bring the catalytic converter up to proper operating range.

7. Discuss Information Sheet, Section VII, emphasizing the addition of rhodium for control of NOx in three-stage converters. Explain that three-stage converters are also called *three-way* or *dual-bed* catalytic converters, and that proper operating temperature ranges from 400°F to 450°F (220°C to 260°C) at the skin, with temperatures up to 1400°F (760°C) inside the converter.

8. In discussing Information Sheet, Section VIII, explain that most of the problems the service technician will encounter are not new; use Supplement #35 to remind students of possible problem areas that may appear to be computer control problems.

9. Use the materials in Information Sheet, Section IX to properly orient students to the special test equipment and procedures required for automotive computer systems.

a. Use Supplements #36 through #38 to discuss the "check engine" light test.

b. Use Supplements #39 and #40 to discuss special test equipment tests.

c. Use Supplements #41 and #42 to discuss voltmeter quick tests.

d. Use Supplement #43 to discuss vacuum gauge quick tests.

e. Emphasize that quick-test procedures must be followed exactly; point out that most parts supply agencies will not accept returns of electronic parts.

f. Emphasize that the service technician must take care to use the correct procedure and charts for each particular make and model as equipped. Point out that a code 23 for one vehicle may not be the same as a code 23 on a different make, and that the code 23 procedure for a 1984 vehicle may not be the same as that used on the 1983 model.

g. Mention that codes stored in the computer memory are automatically erased if they do not recur within a certain number (such as fifty) engine starts.

h. Emphasize that if more than one code is received in the quick test, service procedures should begin with the lowest code number.

i. Use Supplements #44 and #45 to help clarify the use of the quick-test chart and to introduce Information Sheet, Section X.

10. Discuss Information Sheet, Section X, using manufacturer's service manual to show how the quick-test chart directs the service technician to a pinpoint test.

a. Use Supplement #46 to introduce test procedures, and Supplement #47 to demonstrate the use of the chart.

b. Have students complete Assignment Sheet #1 so that they may practice using diagnostic charts.

11. Use Supplements #48 and #49 when discussing special test equipment outlined in Information Sheet, Section XI. Emphasize that any equipment used must be designed for use with a particular make and model as equipped. Emphasize that short circuits and incorrect voltages can easily burn out electronic equipment.

a. When discussing the digital voltohmmeter (DVOM), mention that automotive service technicians are now required to work with sensitive electronic equipment requiring extremely accurate measurements.

EXAMPLES: Oxygen sensor operating range 250 to 1400 millivolts, coolant temperature sensor resistance of 70 to 100,000 ohms

SUGGESTED ACTIVITIES

b. Use Supplement #49 to discuss spark-tester adapters; explain that all computer systems must be connected correctly, and must be *properly grounded* because open circuits and inadequate grounding may lead to erroneous readings or equipment damage.

c. Use Supplement #49 to discuss hand-operated vacuum pumps and jumper leads.

d. Use Supplement #48 to discuss tachometers and timing lights.

e. Use Supplement #48 to discuss tachometers, timing lights, and dwell meters; point out that some models of dwell meters offer too much resistance to be used with electronic circuits; emphasize that the dwell meter must be calibrated to the circuit in accordance with the manufacturer's instructions.

12. In discussing Information Sheet, Section XII, point out that automotive electronic systems are very sensitive in their circuitry requirements; therefore, it is vitally important that care be used in connecting and disconnecting components, selecting circuitry wiring, and splicing and insulating circuits.

a. Use Supplements #50 and #51 to discuss blade-type and pin-type connectors.

b. Use Supplement #52 to discuss the weather-pack terminal.

1) Emphasize that a special tool or small drift punch is required to push the terminals from the retainer; point out that use of other tools, such as an ice pick, may damage the pins.

2) Emphasize that bent pins cannot be straightened, and that damaged components need to be replaced.

c. Explain that automotive computer systems operate at such low voltage levels that the current cannot break down corrosion and film buildup.

13. Use Information Sheet, Section XIII and Supplements #53 and #54 when discussing splicing.

a. Emphasize that splices must introduce as little resistance as possible to the system.

b. Remind students that automotive computer circuitry uses current measured in thousandths of an ampere (milliamps) with pressure measured in thousandths of a volt (millivolts).

SUGGESTED ACTIVITIES

I. Provide students with job sheets.

J. Discuss and demonstrate job sheets as required.

1. If possible, provide the students with exposure to many different makes and models of vehicles.

2. Practice with analog equipment may prove helpful as a review for some students.

K. Invite representatives from area dealership service departments to speak to the class about computer systems and special test equipment for their makes of vehicles.

L. Give test.

M. Reteach and retest if necessary.

III. Unit references

A. *C-4 Engine Performance*, 16016.03-1A. Detroit, Michigan: GM Product Service Training, General Motors Corporation, 1980.

B. *Computer Command Control Engine Performance*, 16016.03-1C. Detroit, Michigan: GM Product Service Training, General Motors Corporation, 1982.

C. *Computer Command Control Engine Performance*, SD-TV3-1. Detroit, Michigan: GM Product Service Training, General Motors Corporation, 1981.

D. *Computer Command Control Performance Diagnosis*, 16016.03-3F. Detroit, Michigan: GM Product Service Training, General Motors Corporation, 1981.

E. *Electrical Systems*, 3000-218TXT. Detroit, Michigan: Ford Parts and Service Division, Training and Publications Department, 1978.

F. *Electronic Engine Controls (EEC-111): Description and Operation . . . Systems and Components*, 0901-44. Detroit, Michigan: Ford Parts and Service Division, Training and Publications Department, 1981.

G. *Electronic Engine Controls* (EEC-IV), 0901-046. Detroit, Michigan: Ford Parts and Service Division, Training and Publications Department, 1983.

H. *Engine/Emissions Diagnosis*, FPS-365-126-326 82G. Detroit, Michigan: Ford Parts and Service Division, Training and Publications Department, 1981.

I. "Ford Electronic Engine Control — IV (EEC-IV) System." *Service News Bulletin #83-37*, October 1983. Detroit, Michigan: Ford Parts and Service Division, Training and Publications Department, 1983.

J. *Microprocessor Control Units*, 0901-041. Detroit, Michigan: Ford Parts and Service Division, Training and Publications Department, 1980.

K. *Preliminary 1982 Passenger Car New Product Features*, 10382.00-1. Detroit, Michigan: GM Product Service Training, General Motors Corporation, 1981.

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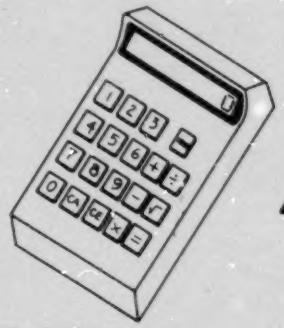
Everyday Computers



4 × 7 = 28

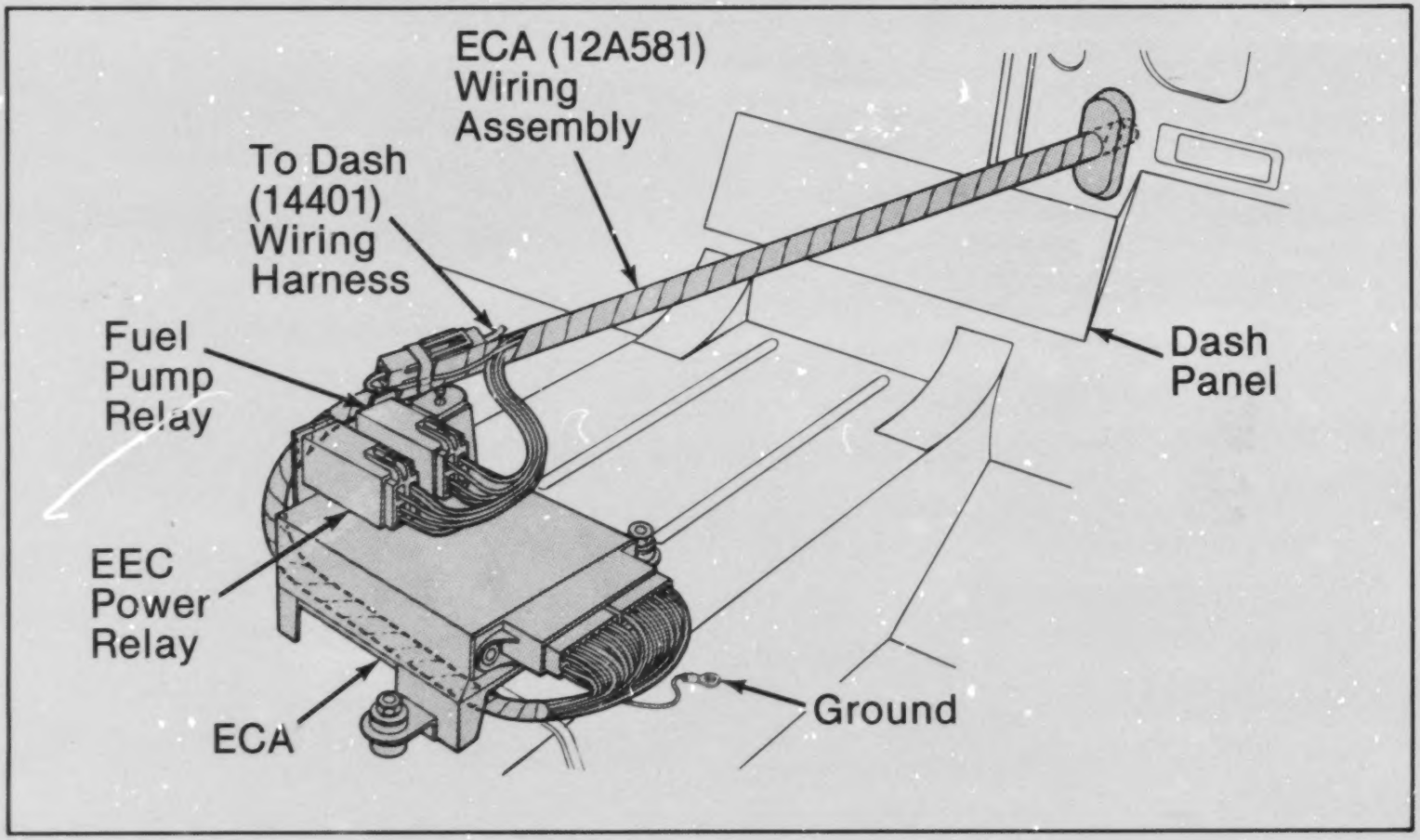
Input

Output

= 28

Automotive Computer Terminology

Ford Electronic Control Assembly (ECA)



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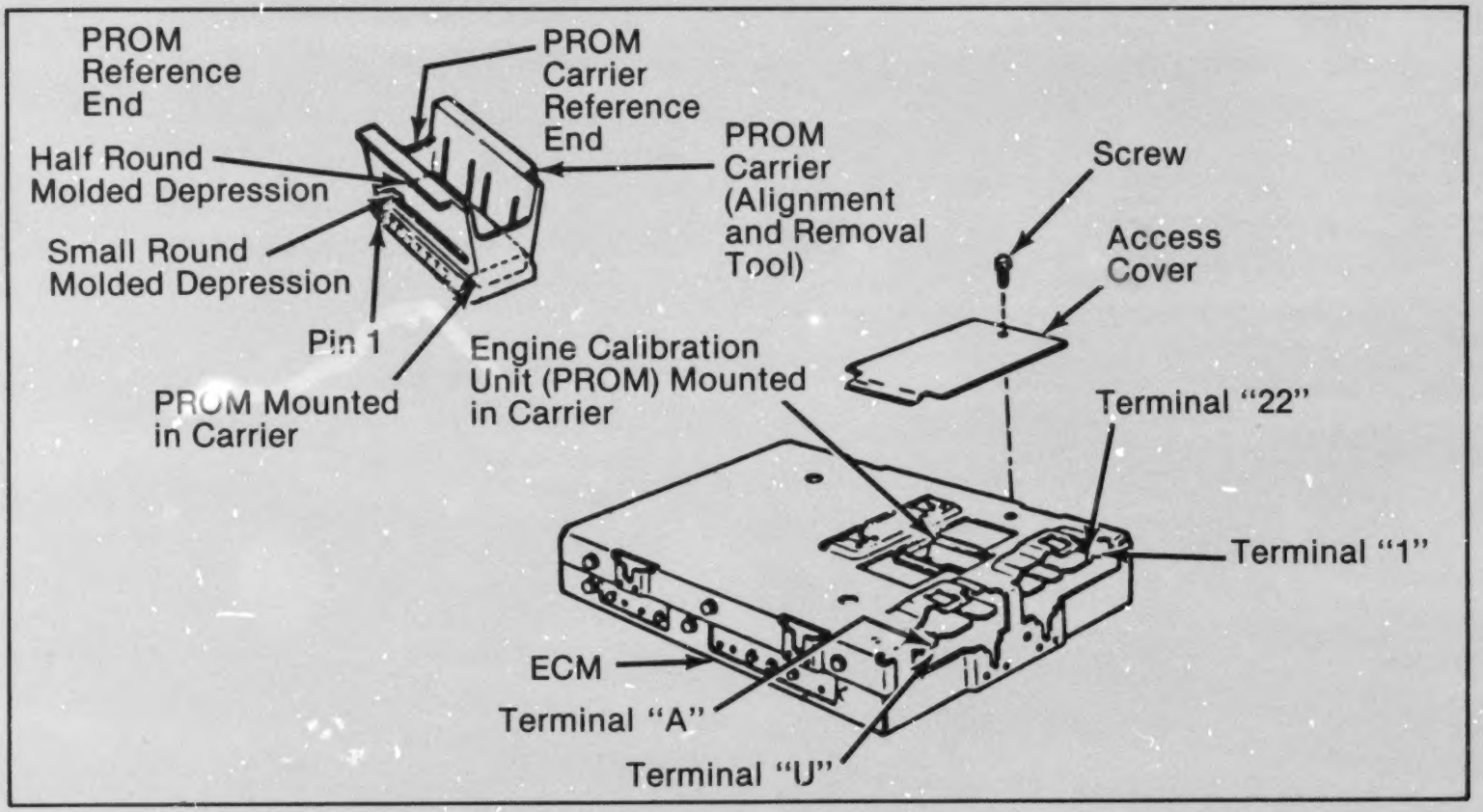
Automotive Computer Terminology

(Continued)

General Motors Electronic Control Module (ECM)



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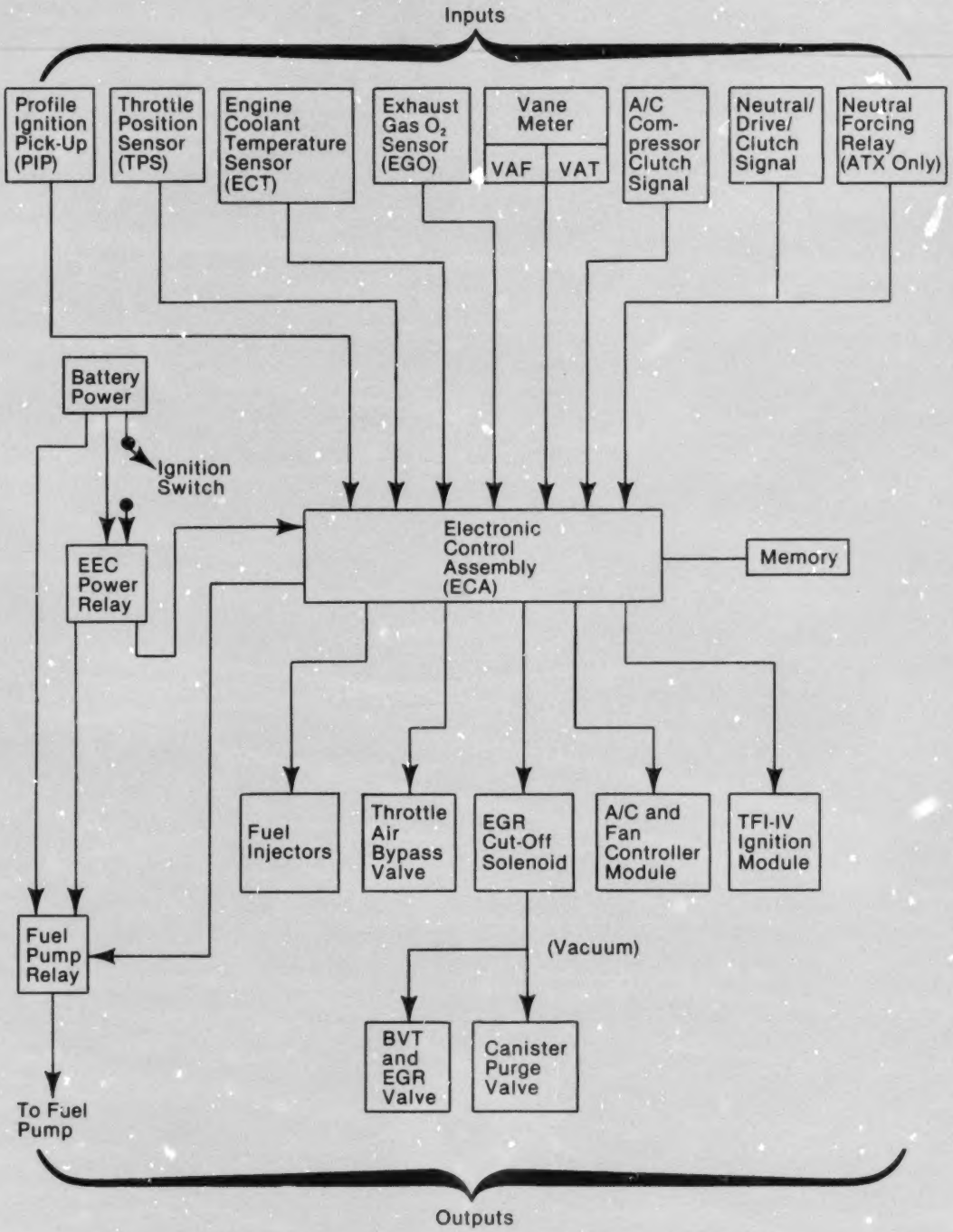
Automotive Computer Functions



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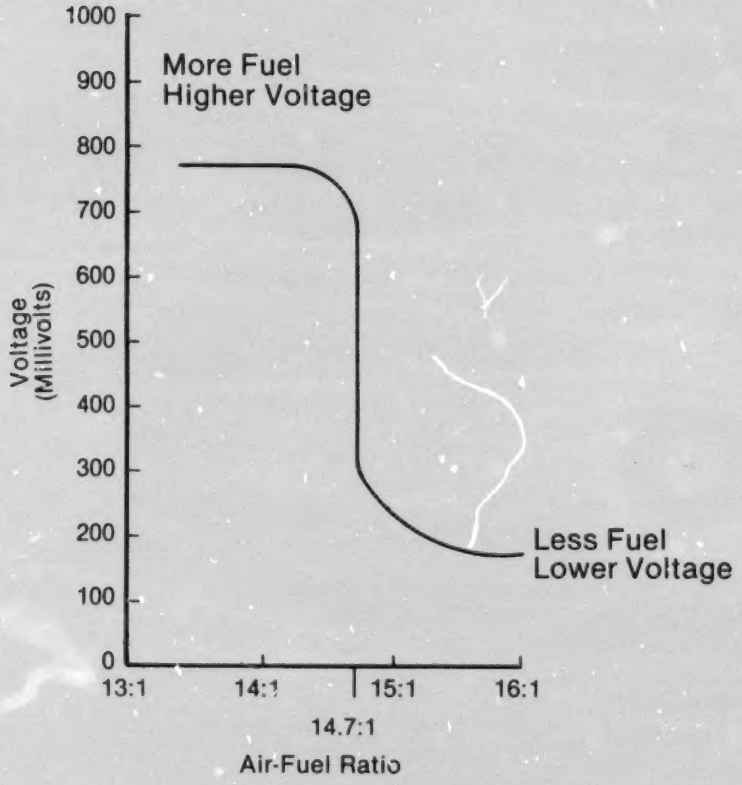
Oxygen Sensor

Exhaust Gas Oxygen Sensor Curve



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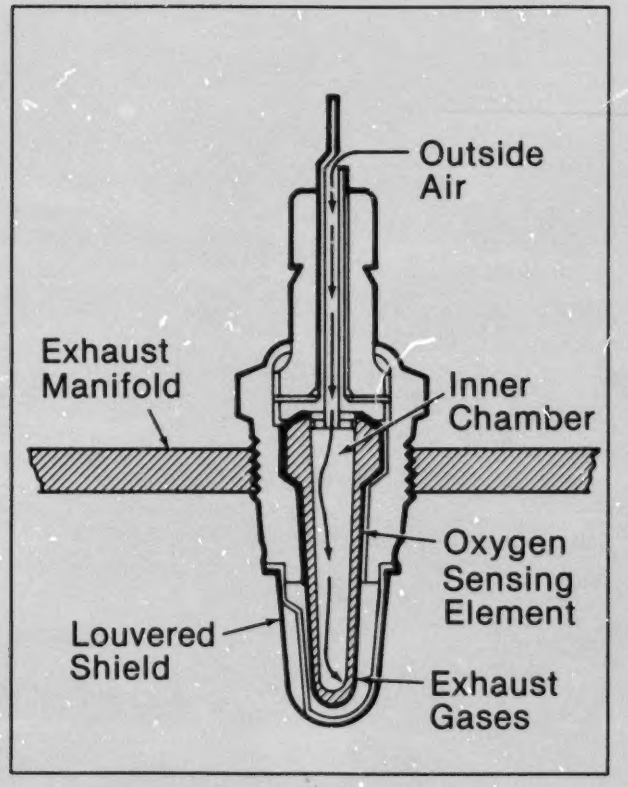
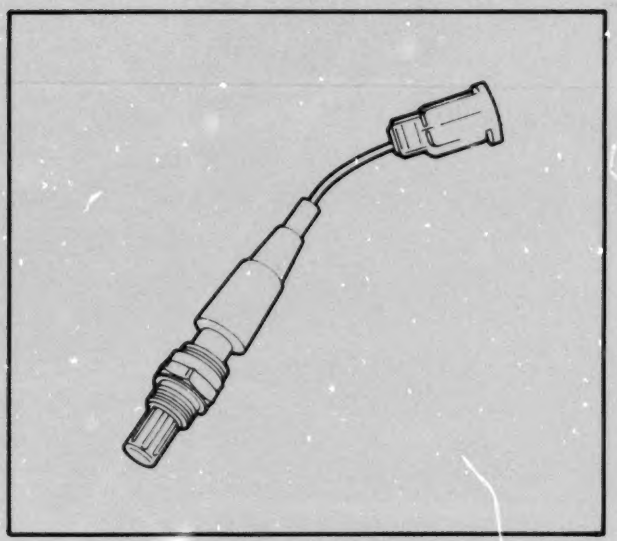


Oxygen Sensors



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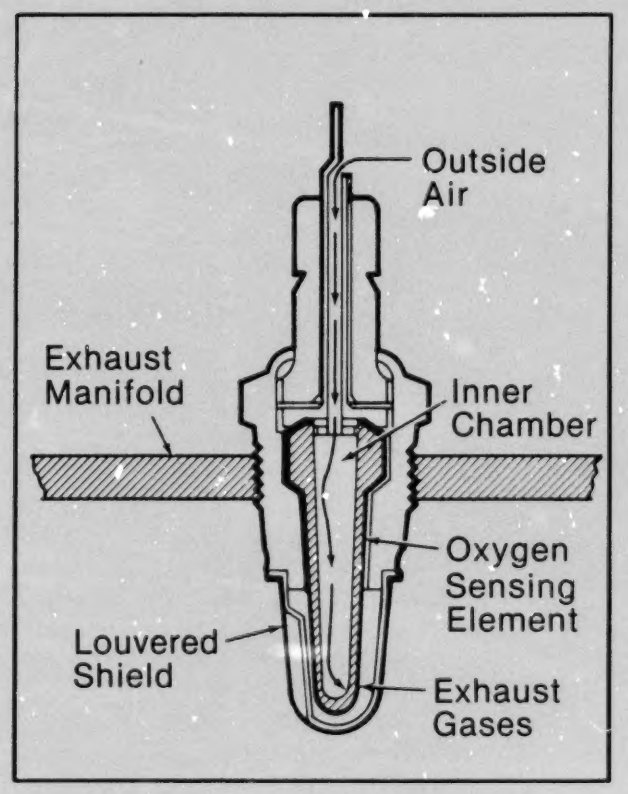

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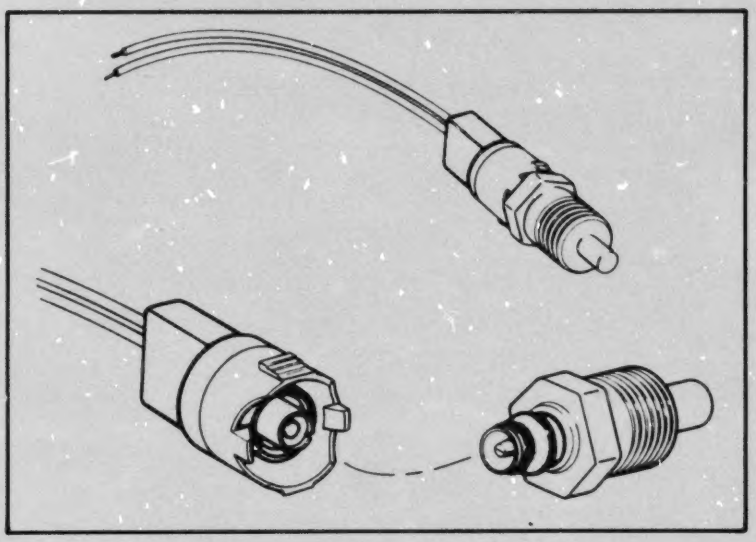
Engine Coolant Temperature Sensors



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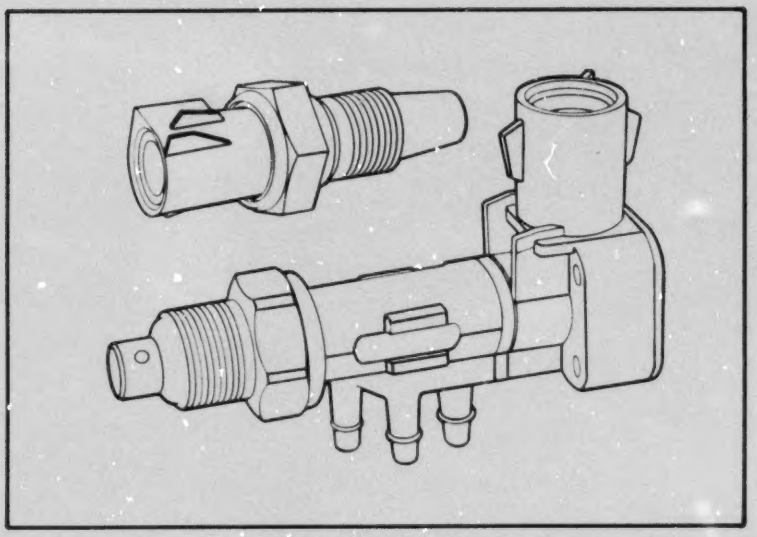

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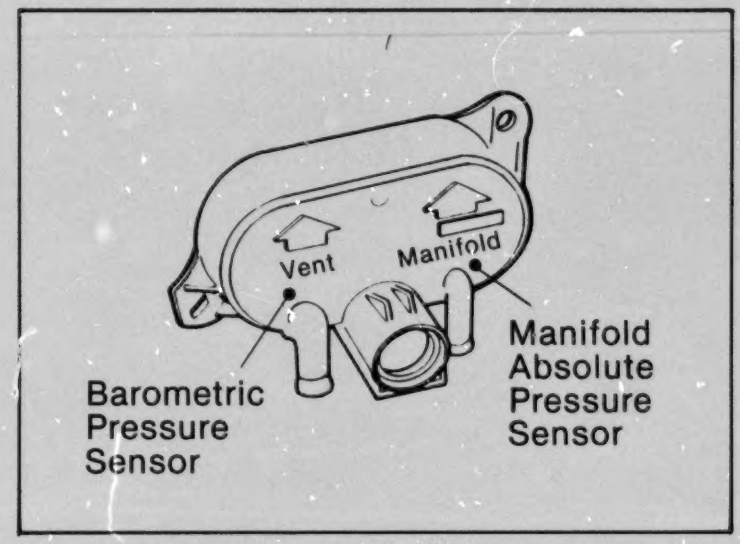
Pressure Sensors

Combination



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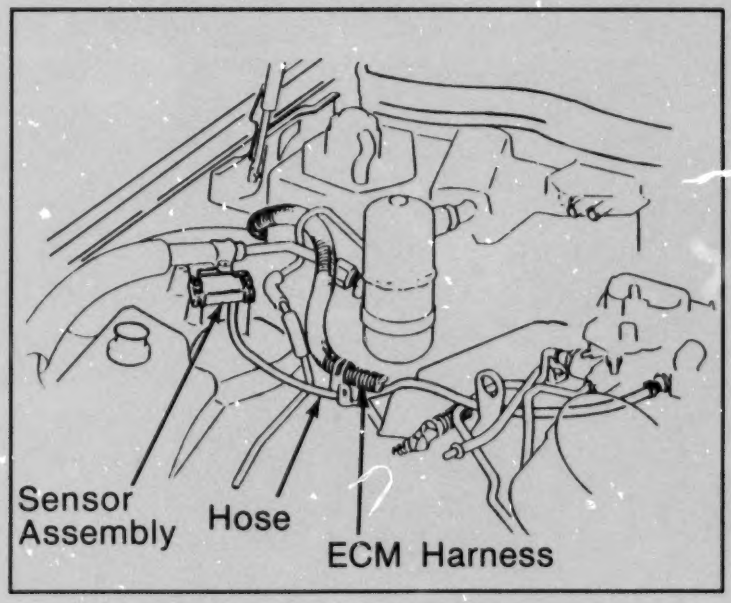
Manifold Absolute Pressure Sensor



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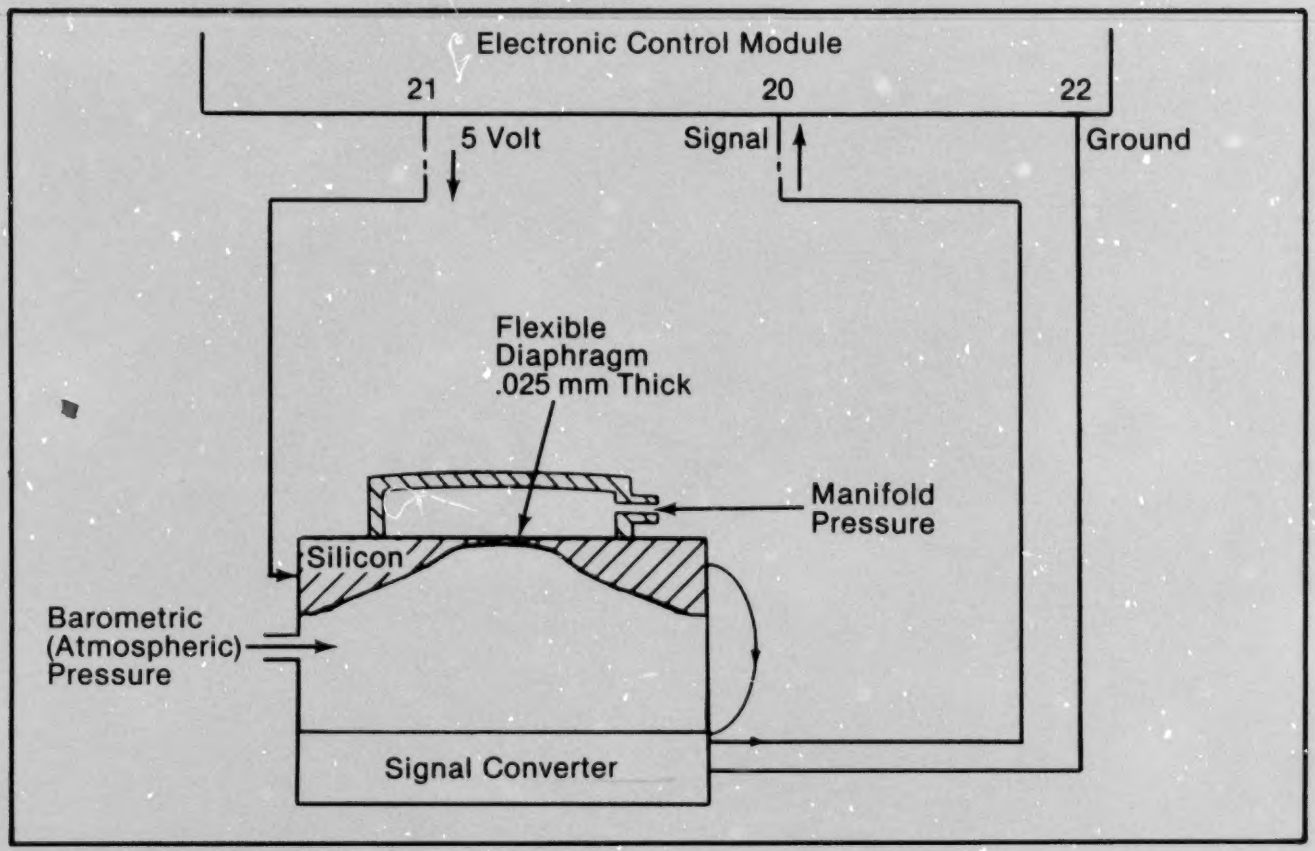
Pressure Sensor Operation

Typical Pressure Sensor (Differential-Type)



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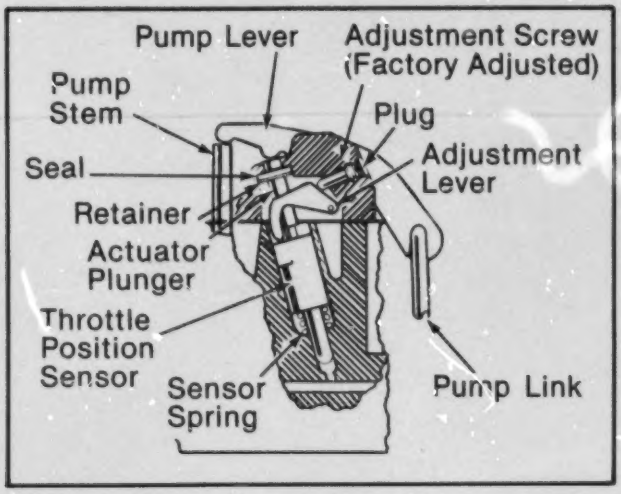
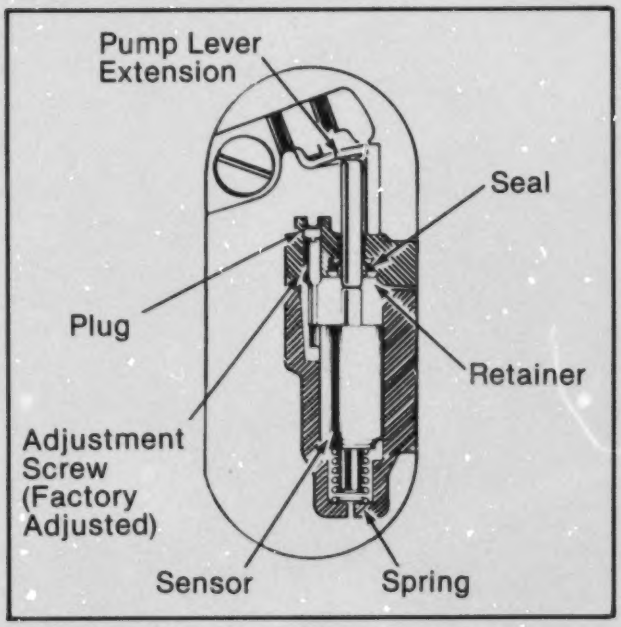
Throttle Position Sensor





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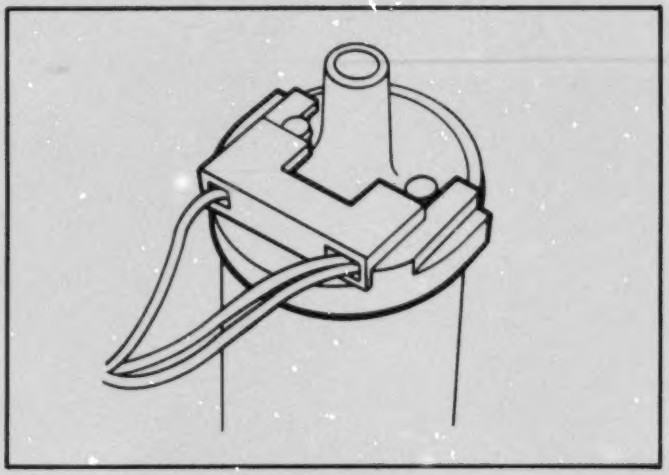
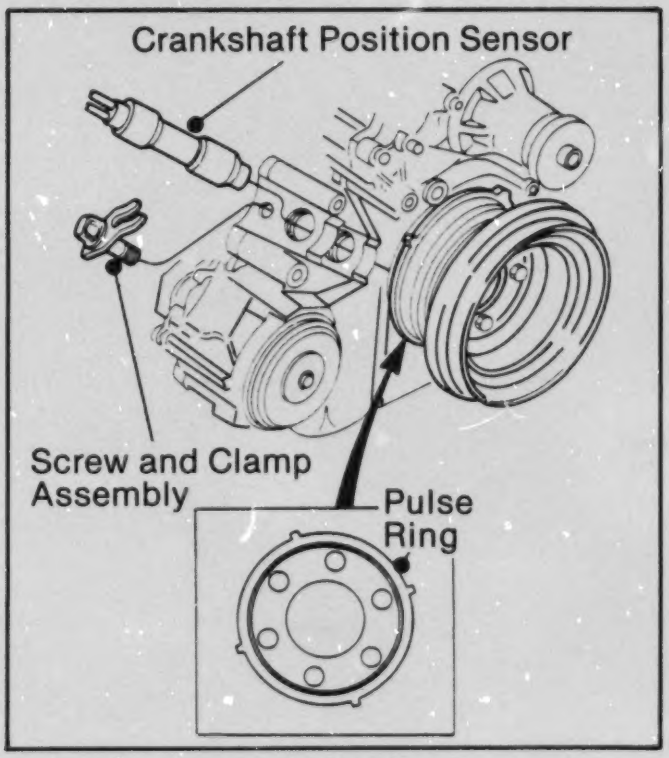
Vehicle Speed Sensors

TACH Input from Coil Horseshoe Connector



Crankshaft Position Sensor



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Vehicle Speed Sensors
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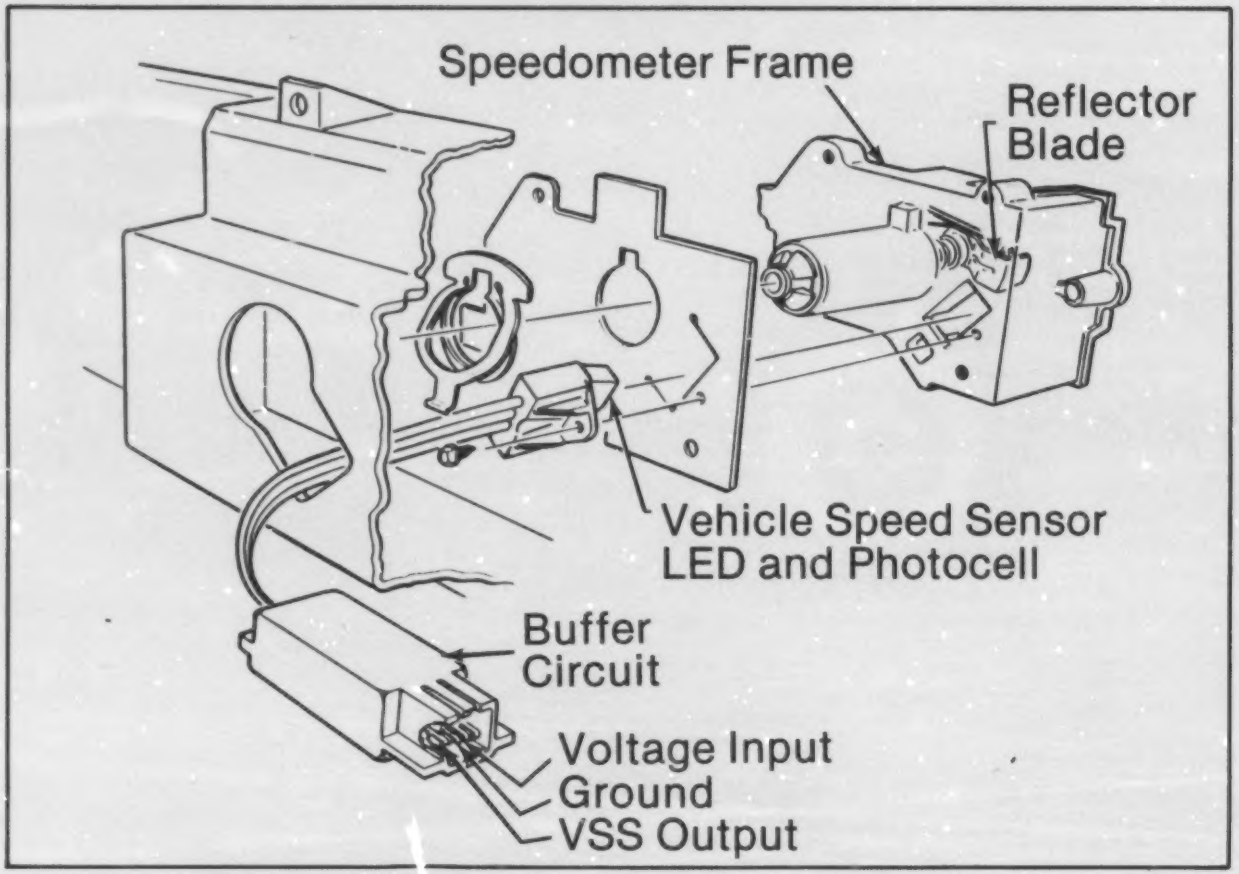

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Vehicle Speed Sensors
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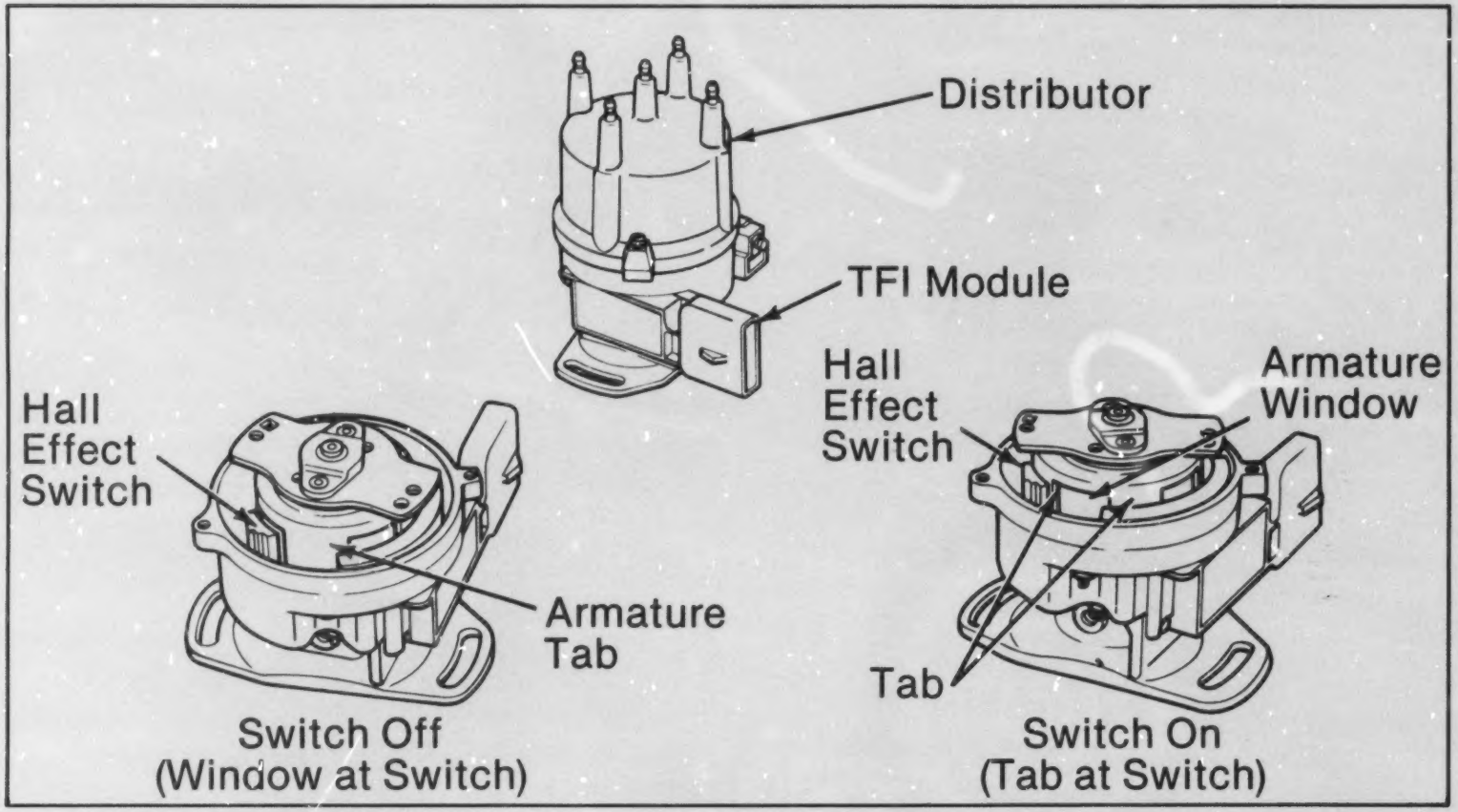

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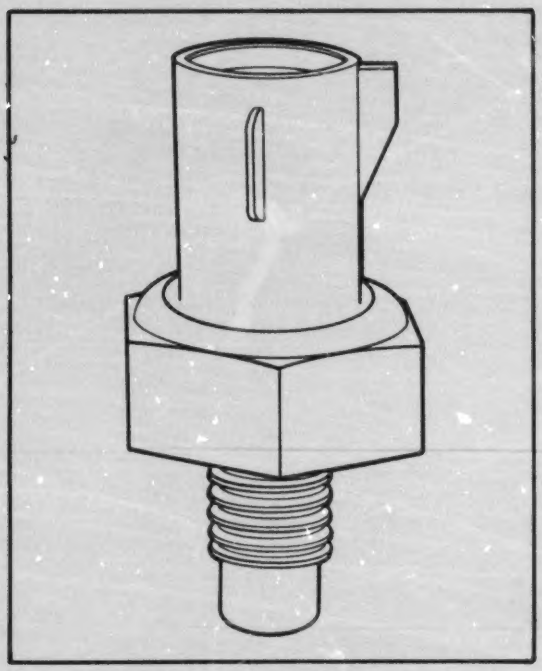
Knock Sensors



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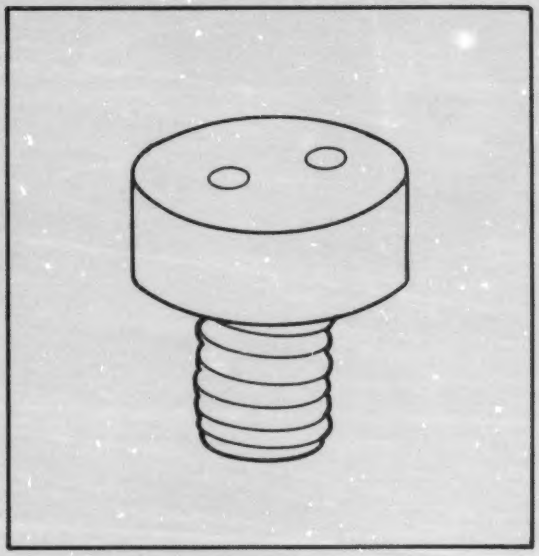

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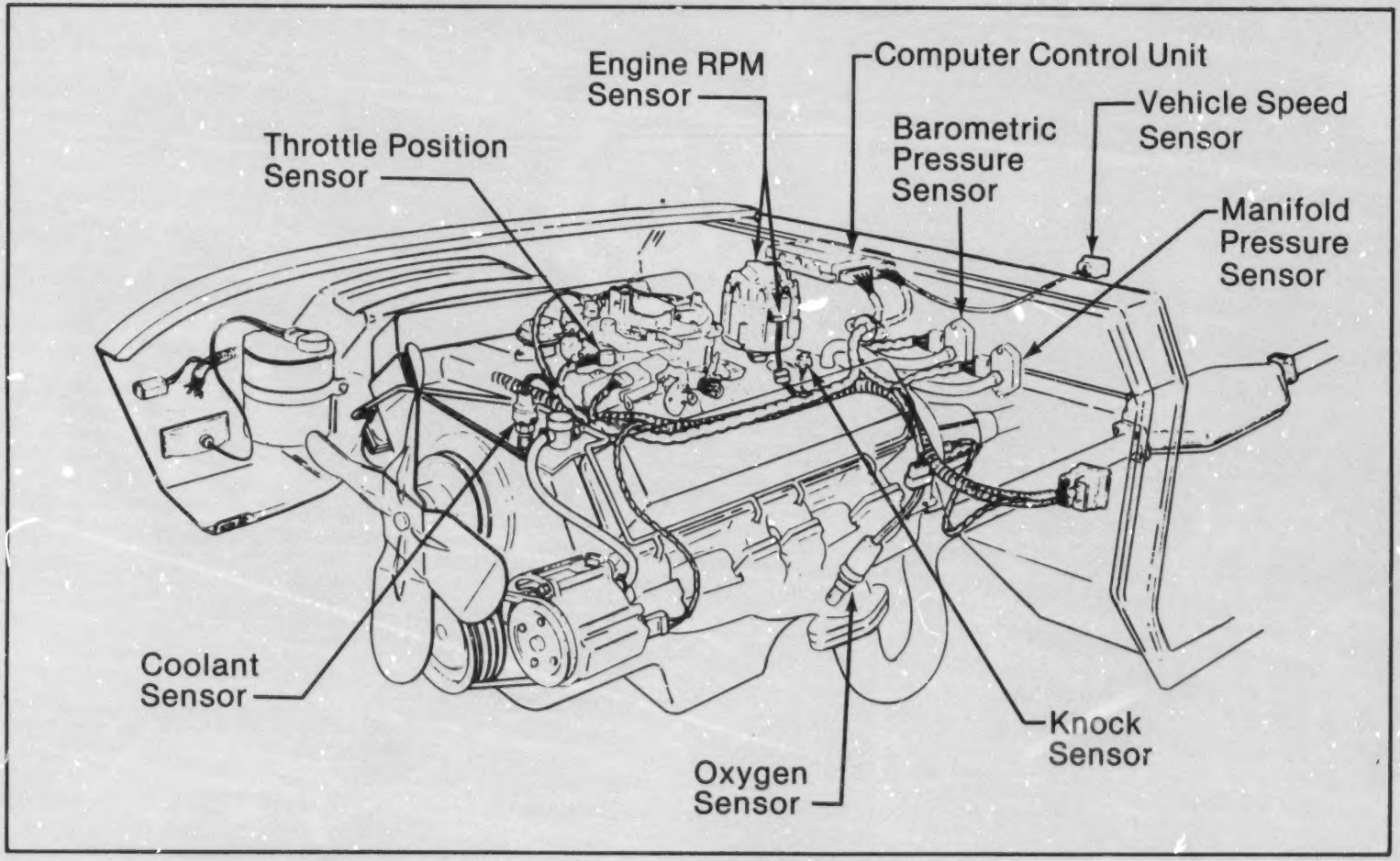
Typical Sensor Locations



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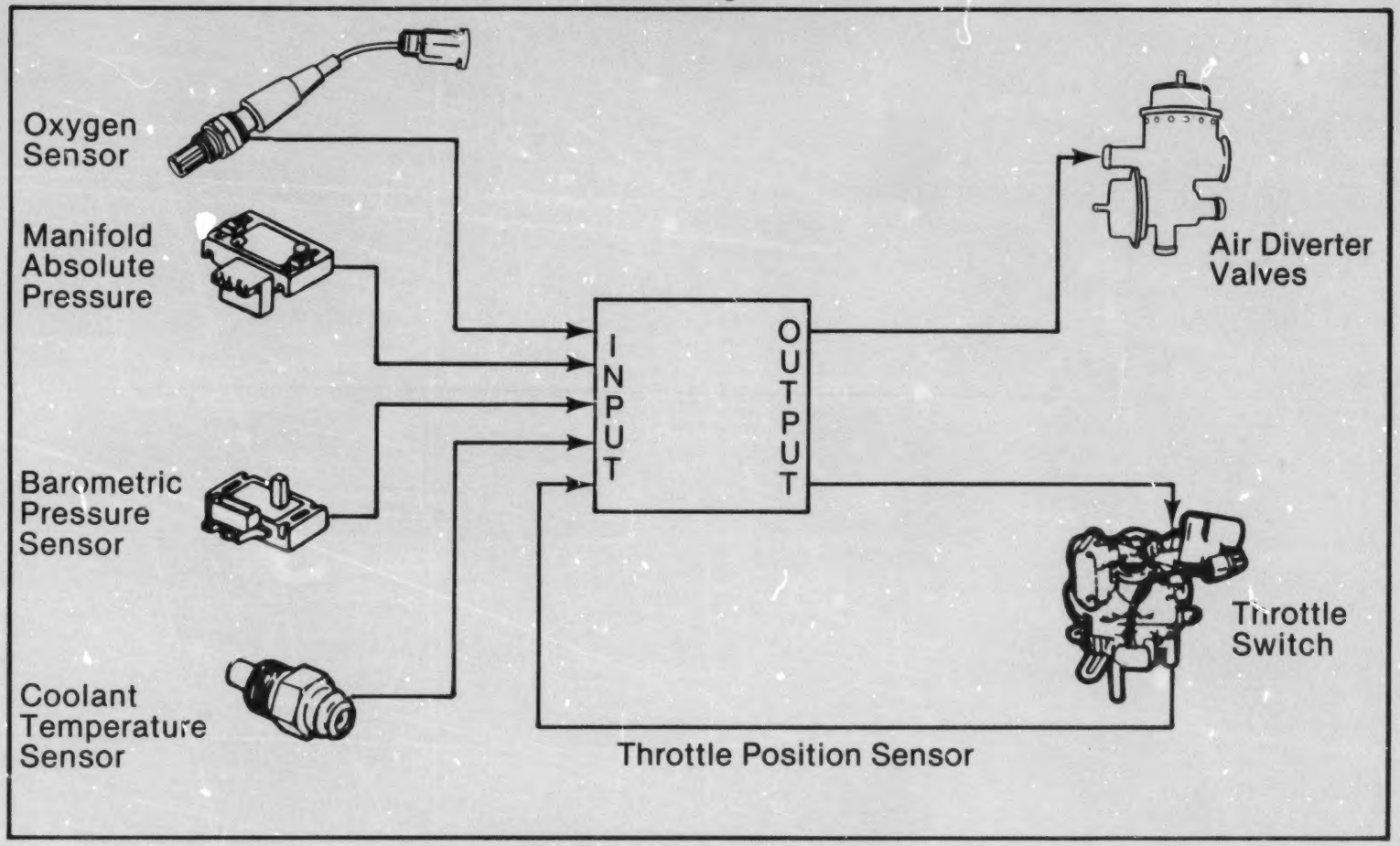
Actuator Response Categories

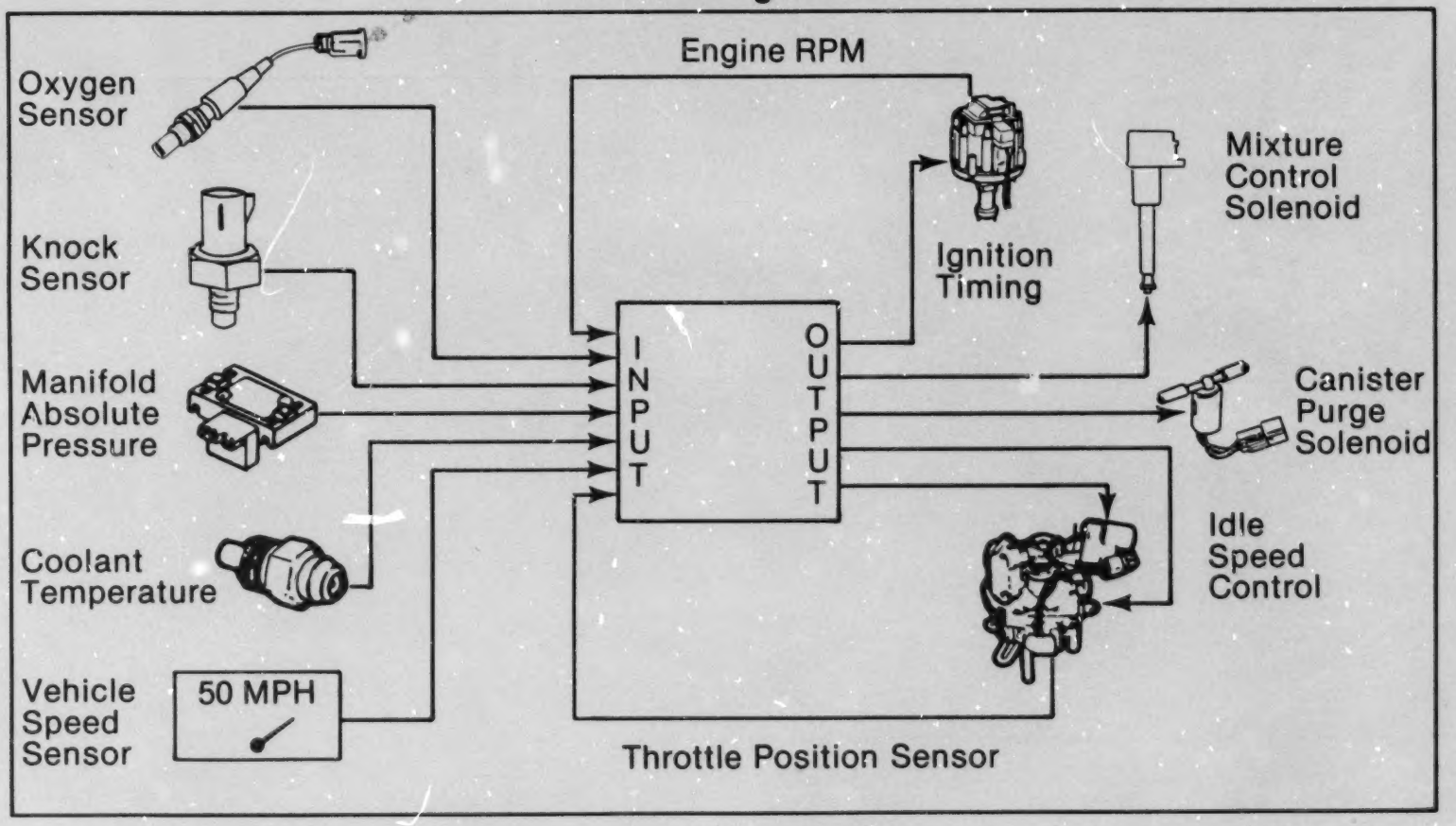
Air Management



Actuator Response Categories

(Continued)

Fuel Management



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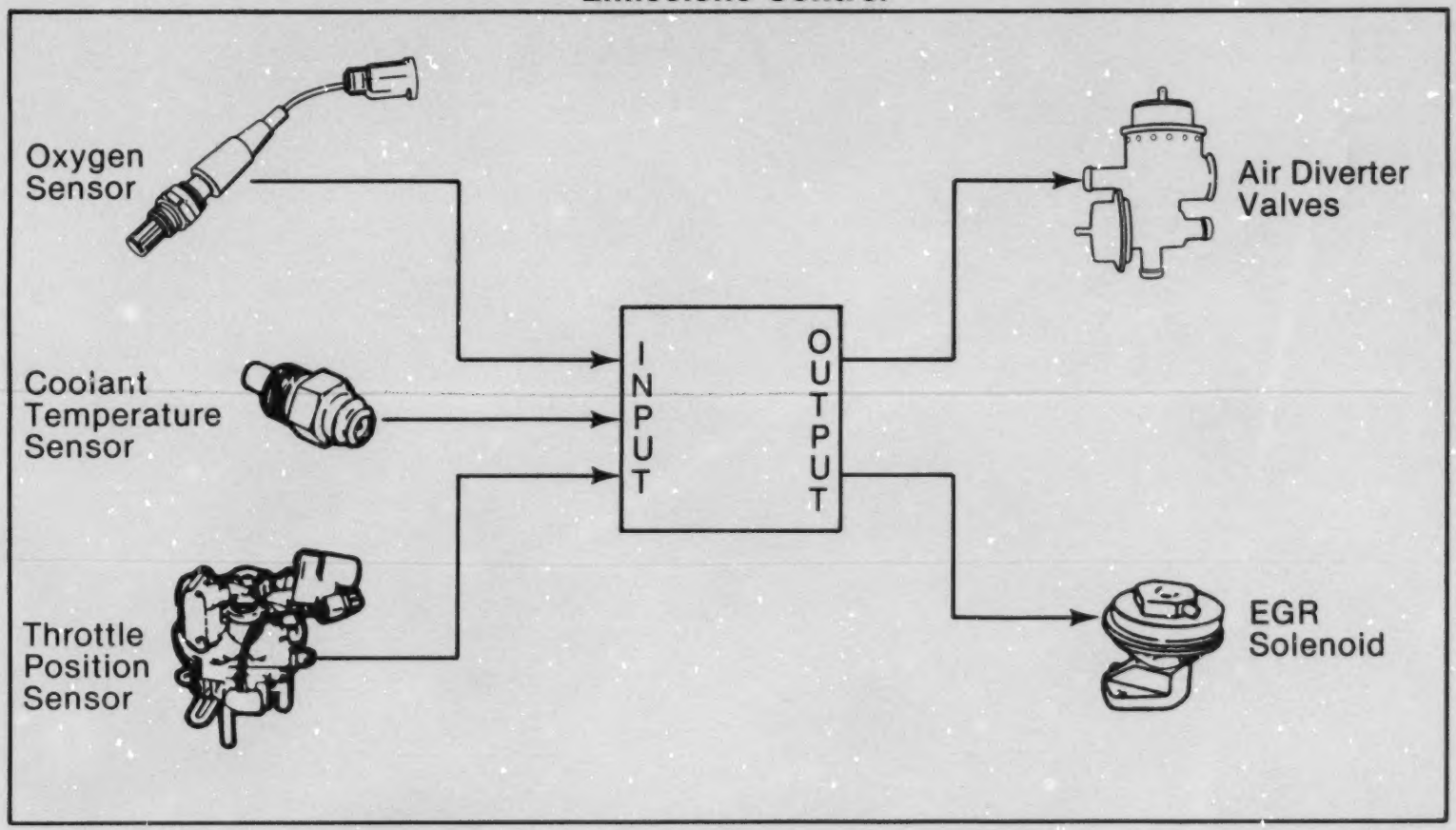
Actuator Response Categories

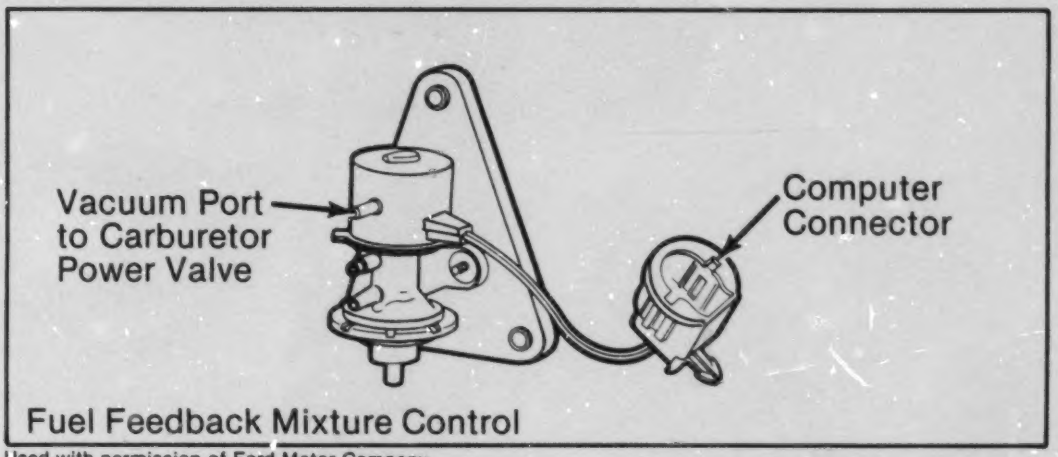
(Continued)

Emissions Control



Carburetor Fuel Controls

Fuel Control Motor



Fuel Feedback Mixture Control

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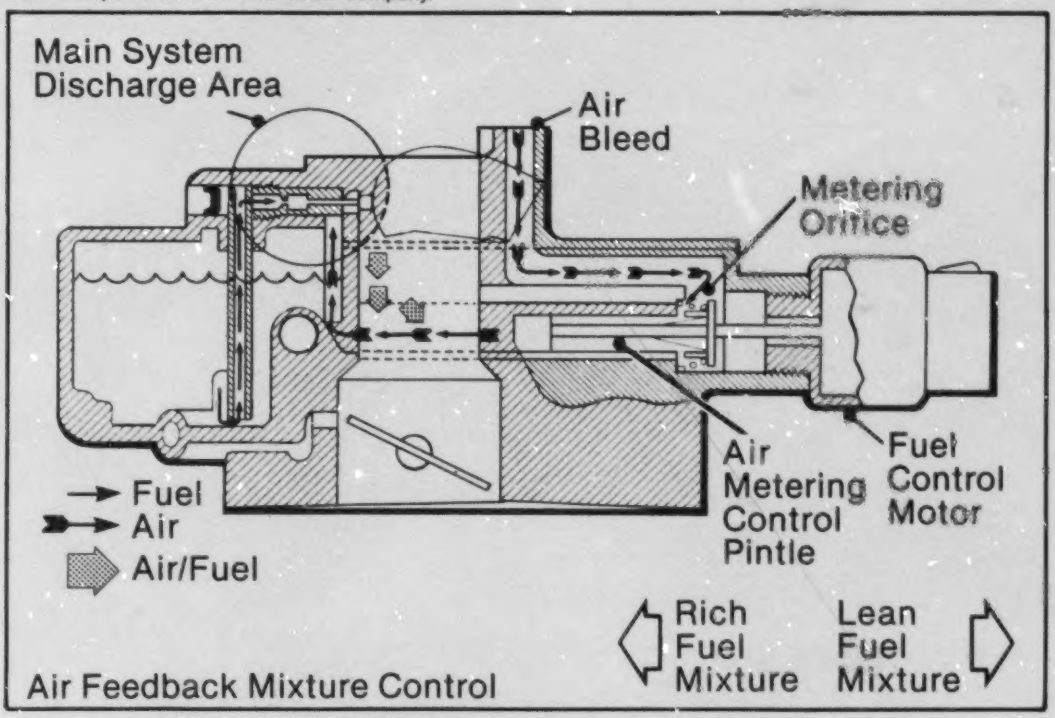

Air Feedback Mixture Control

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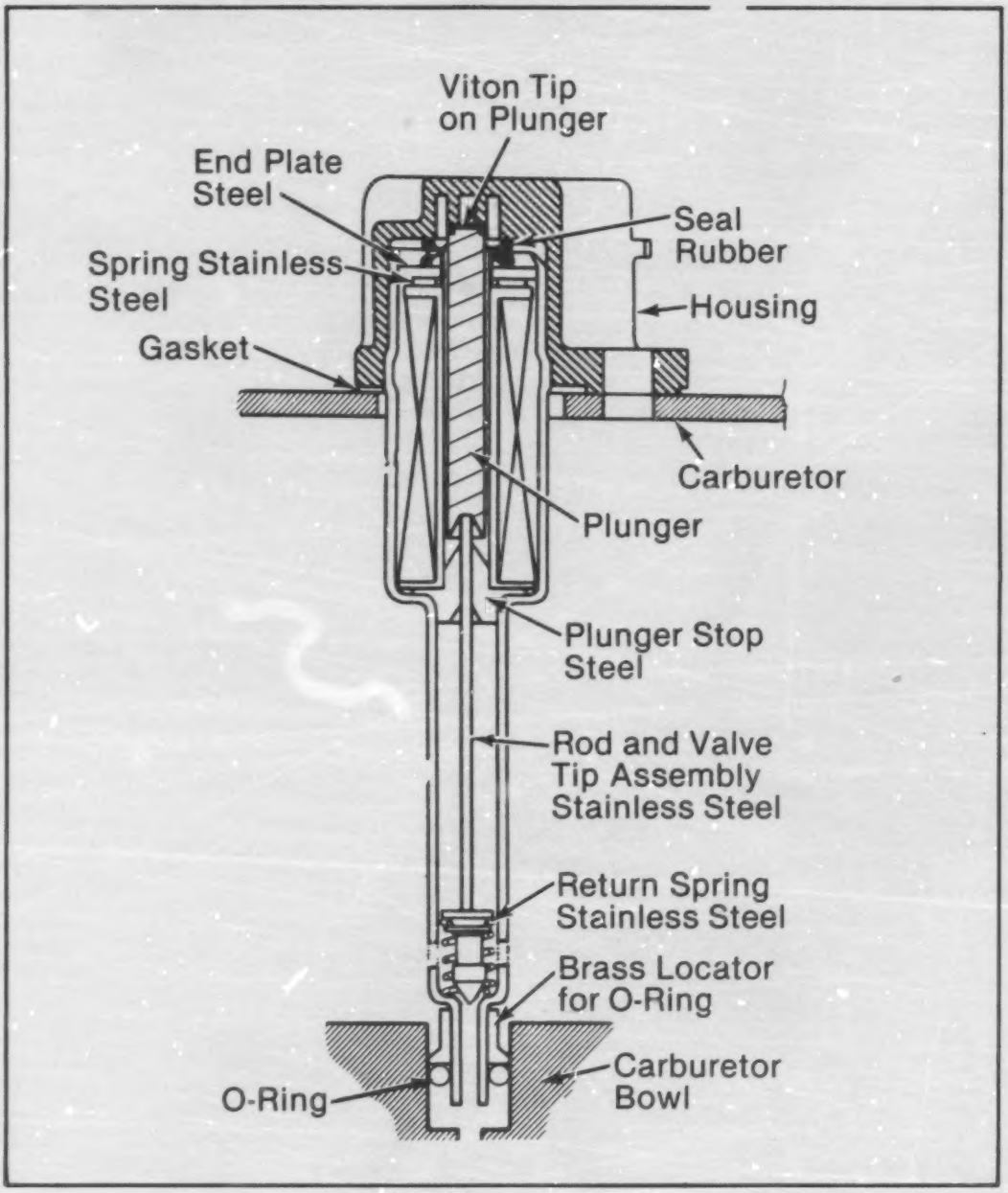
Carburetor Fuel Controls
(Continued)

Mixture Control Solenoid (E25E-Type)



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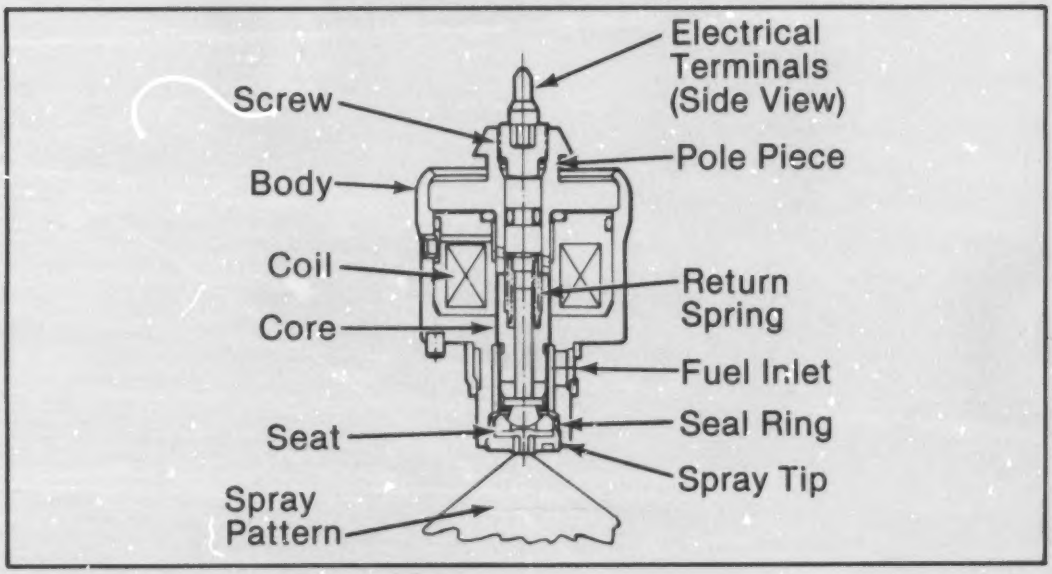
Fuel Injection Fuel Controls

Throttle-Body-Type



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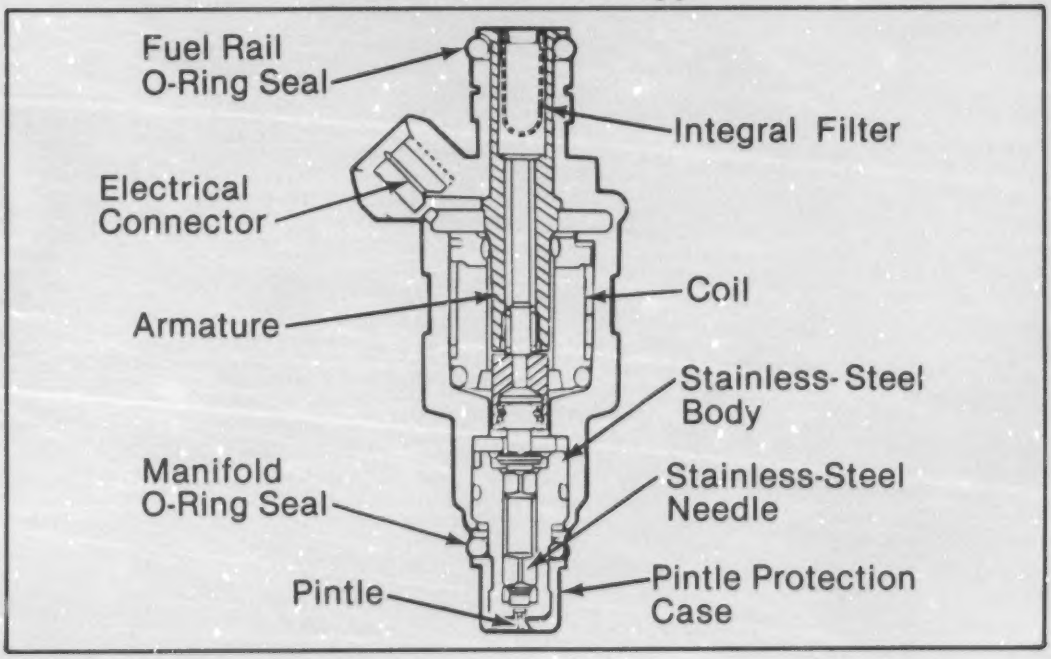
Intake-Manifold-Type



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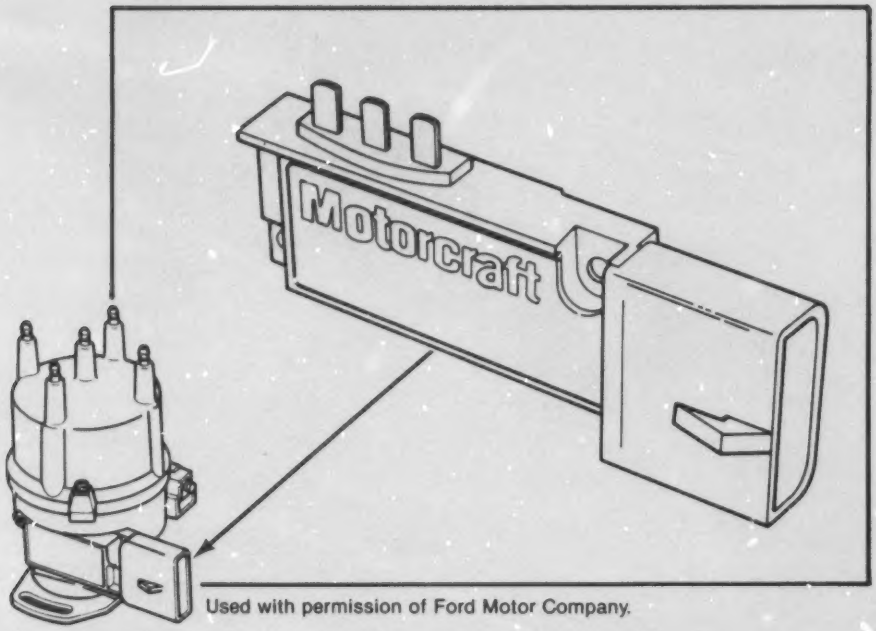
Ignition Timing Controls



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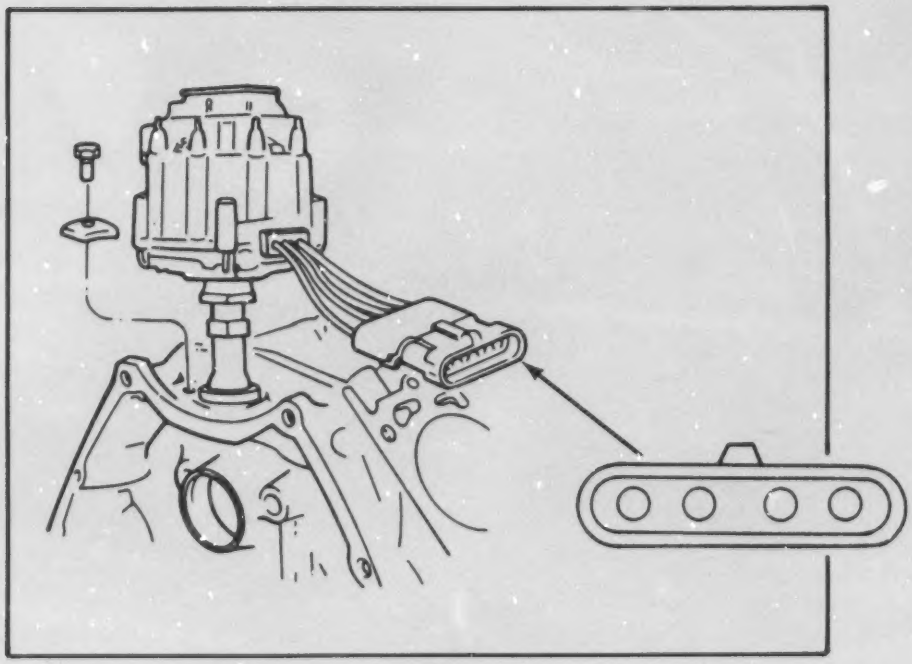

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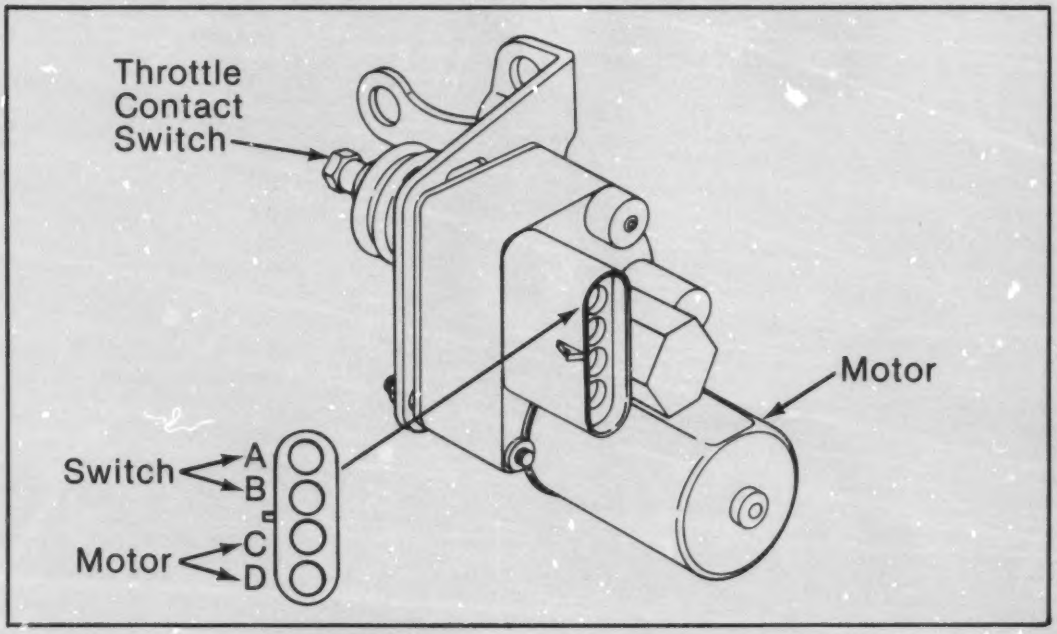
Engine Idle Speed Controls

Engine Idle Speed Control



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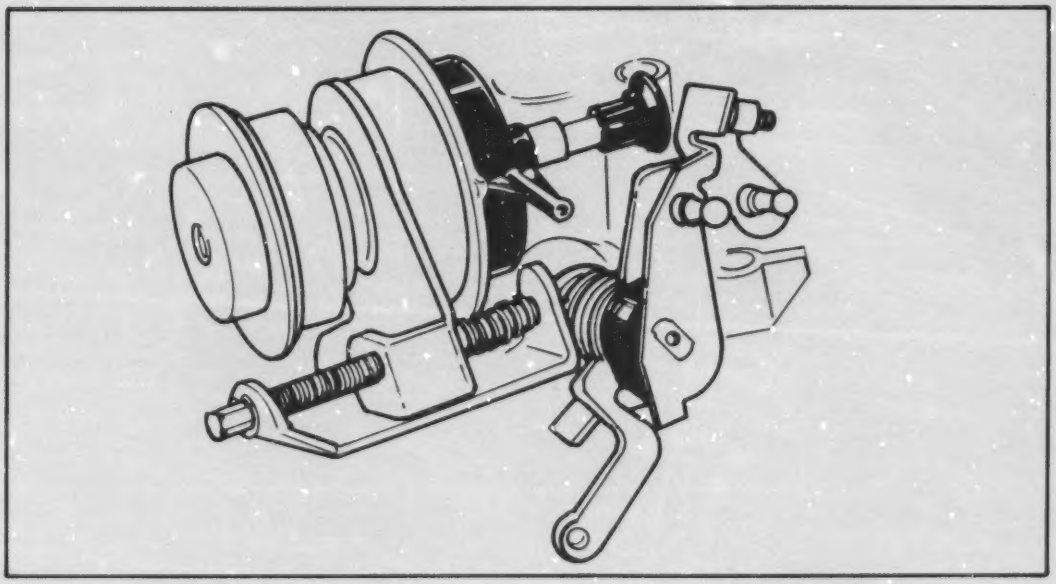
Throttle Kicker Vacuum Motor



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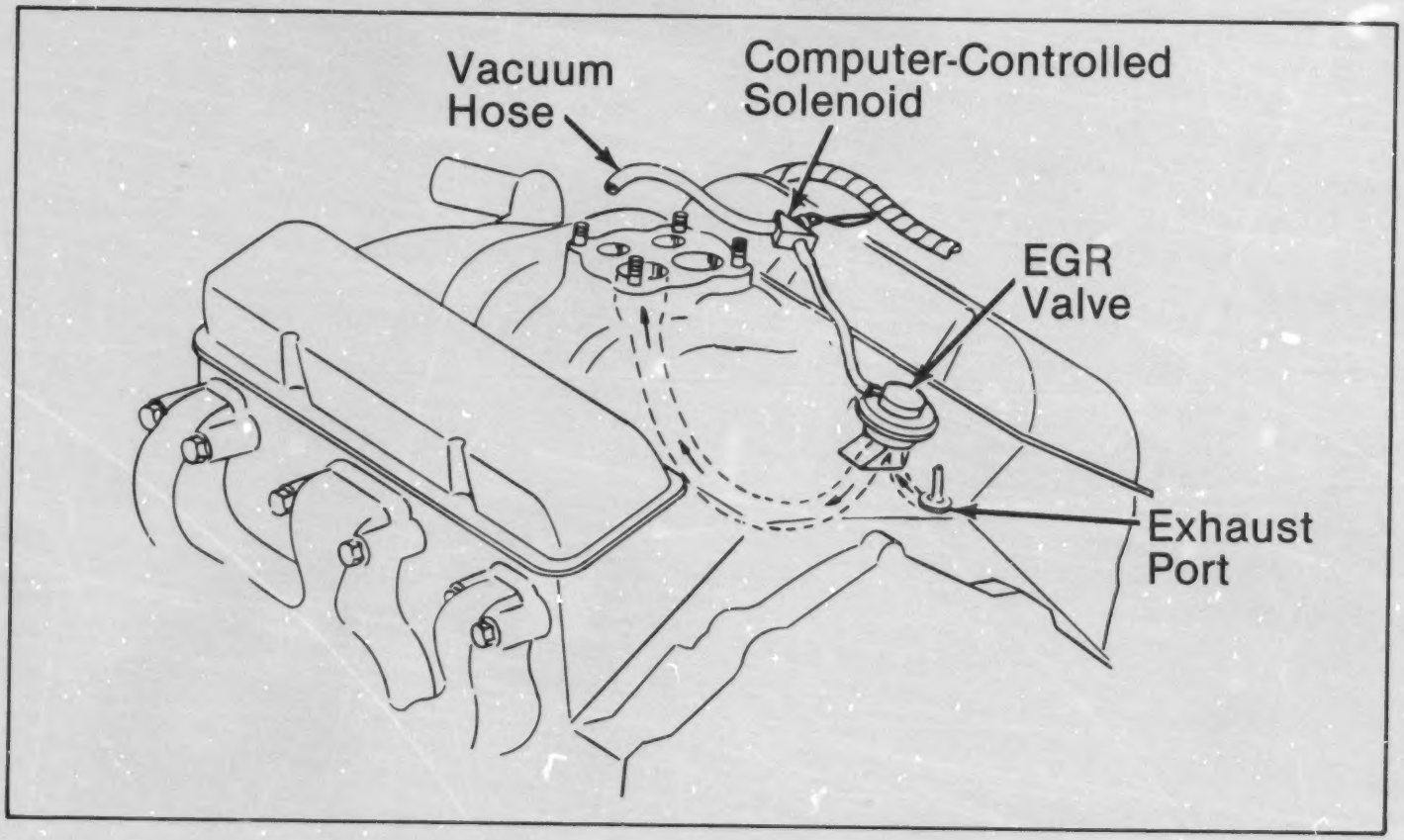
Exhaust Gas Recirculation (EGR)

EGR Valve and Solenoid



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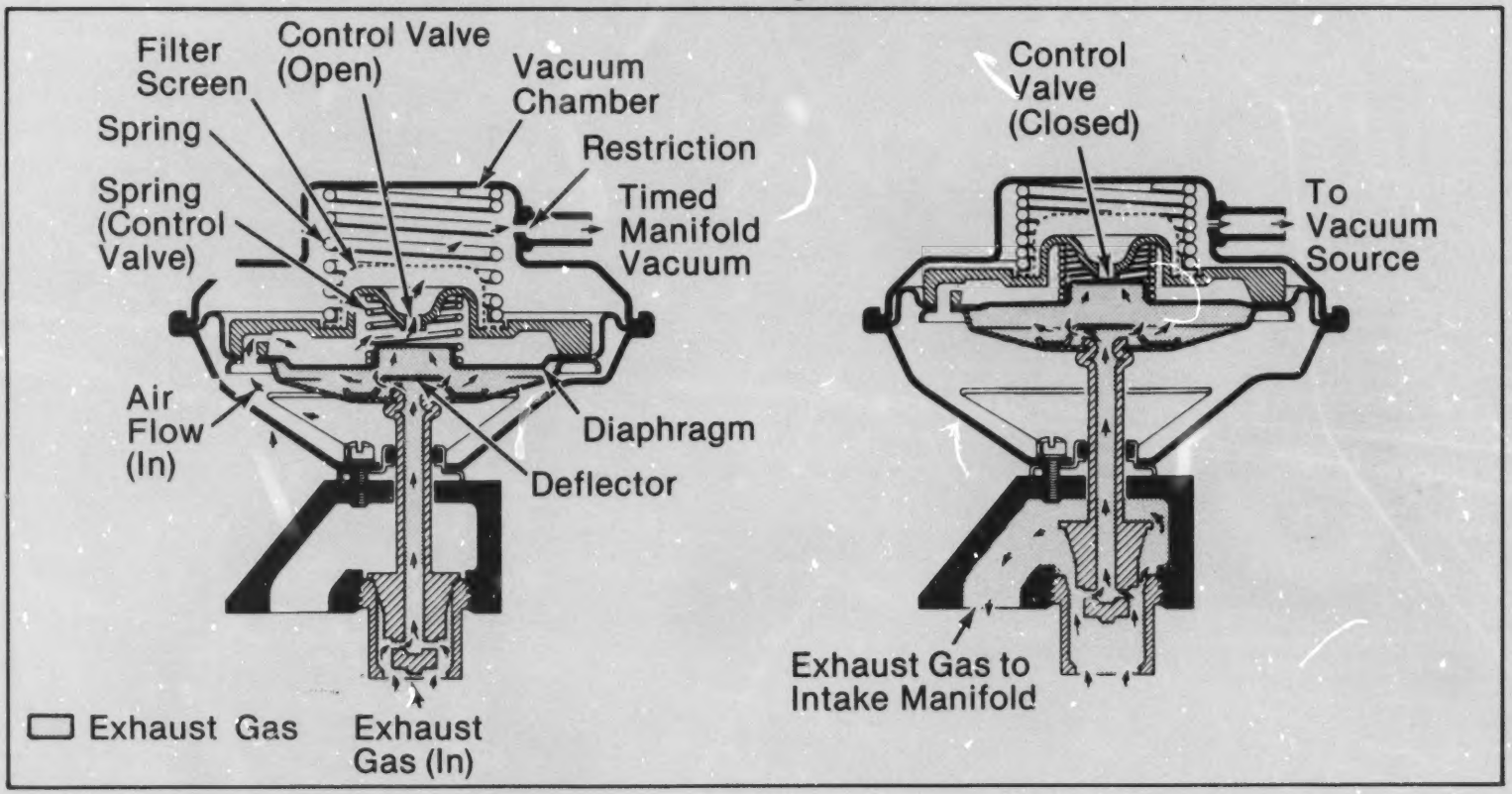
Exhaust Gas Recirculation (EGR)

(Continued)

EGR Valve Operation



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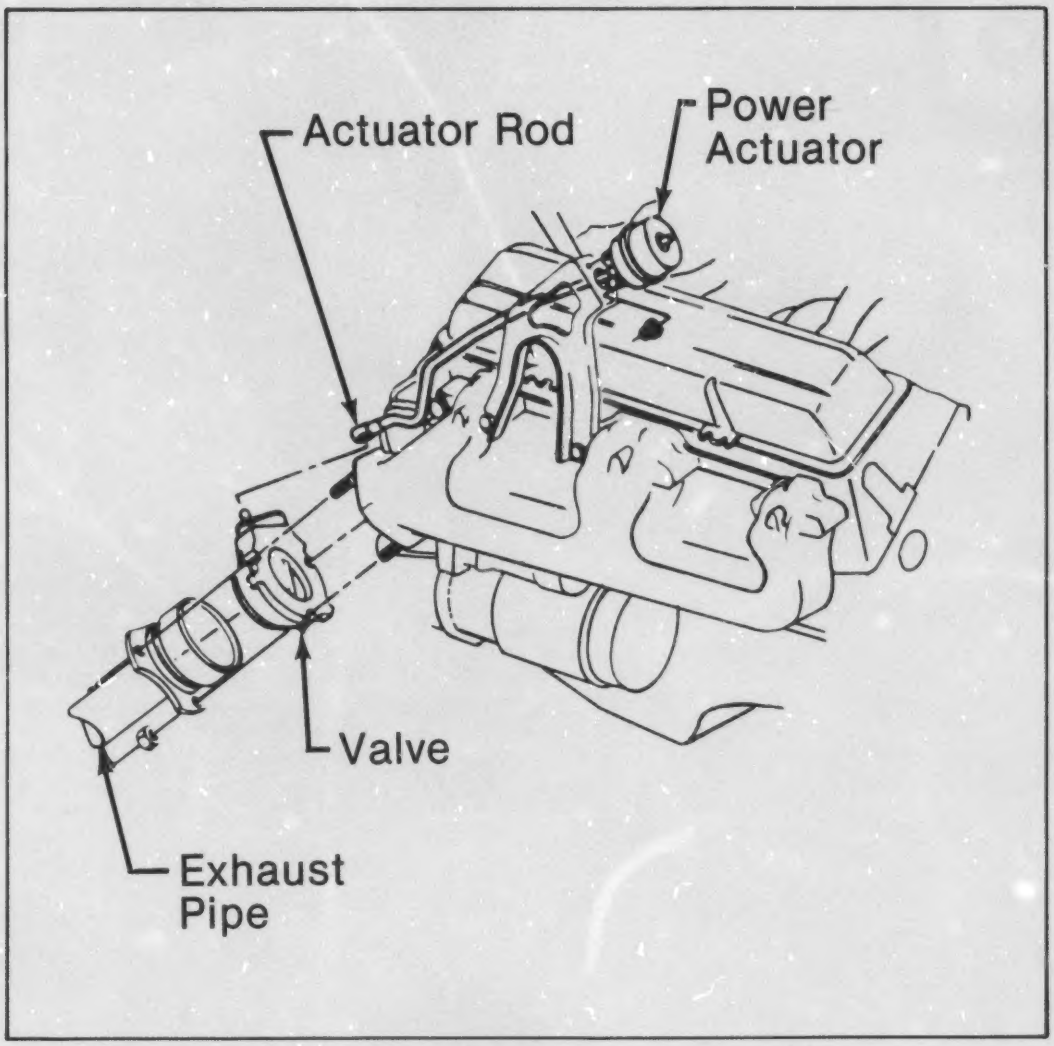
Exhaust Manifold Heat Control



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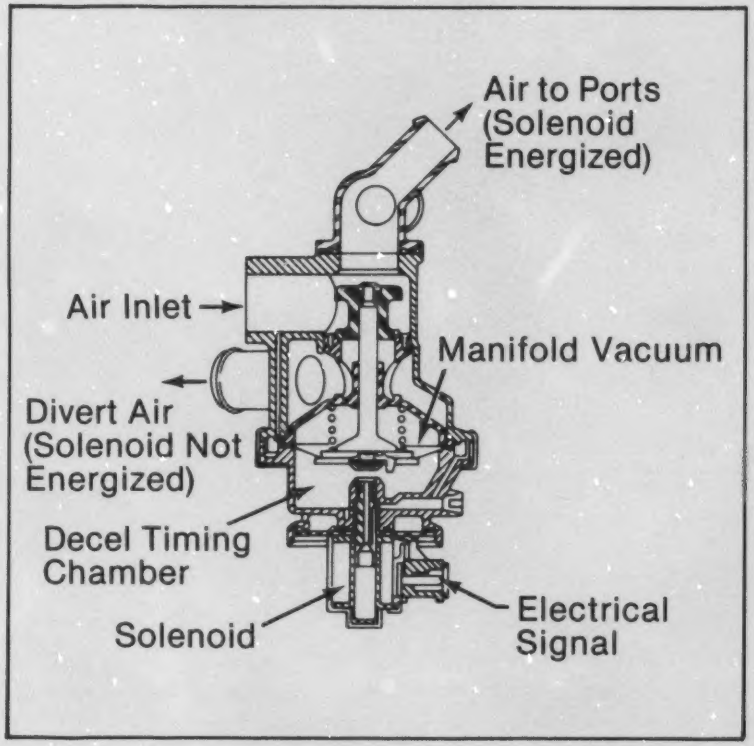
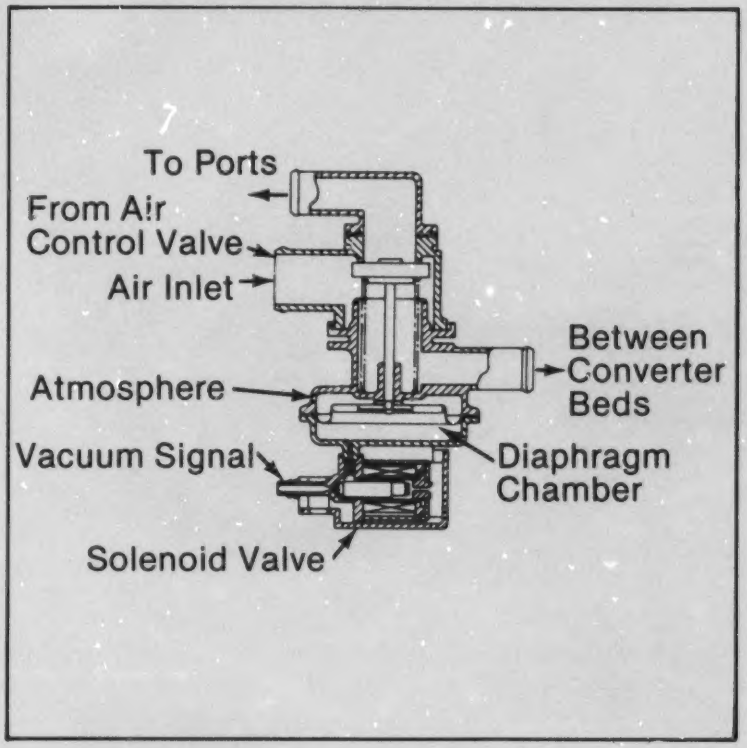
Exhaust Manifold Heat Control
(Continued)

Electric Air Control Valve



Electric Air Switching Valve



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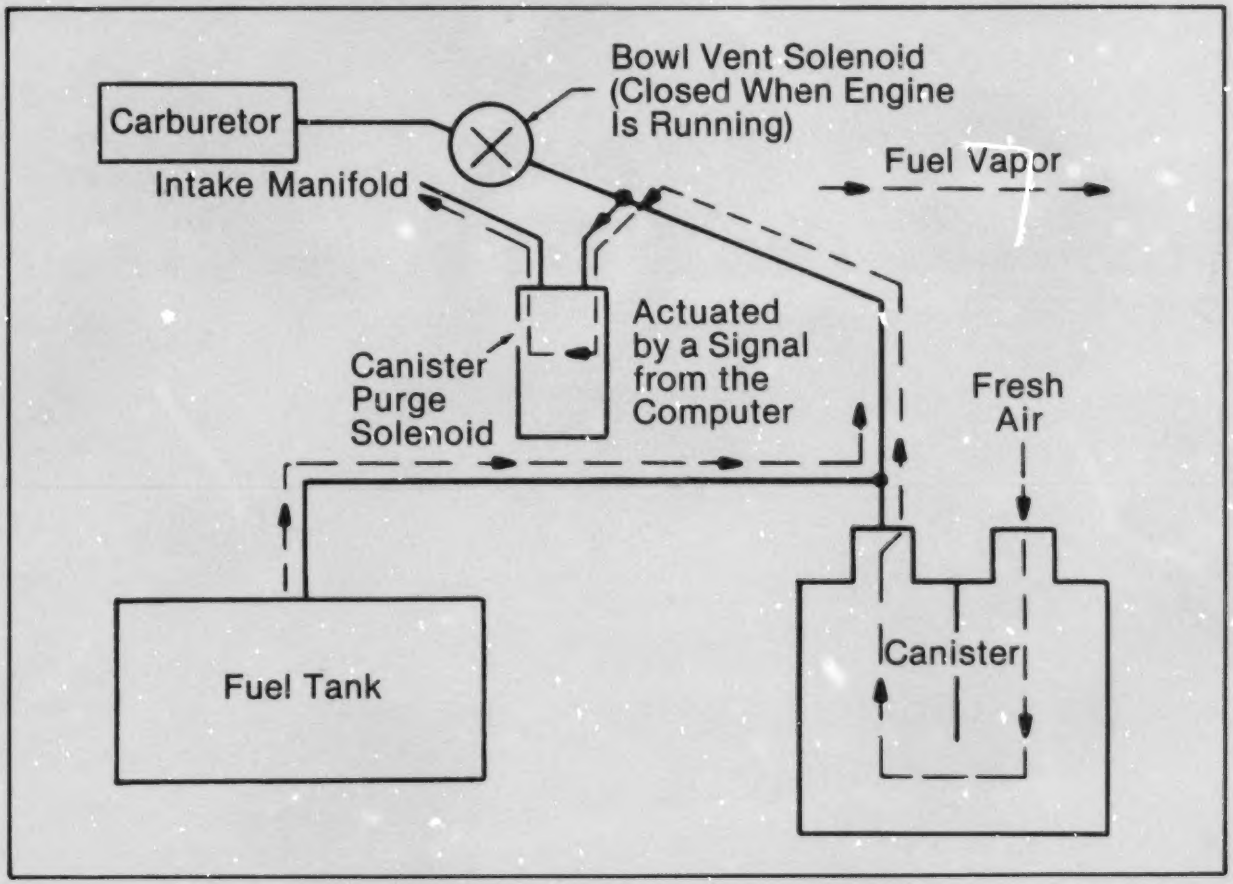
Evaporative Gas Canister Purge



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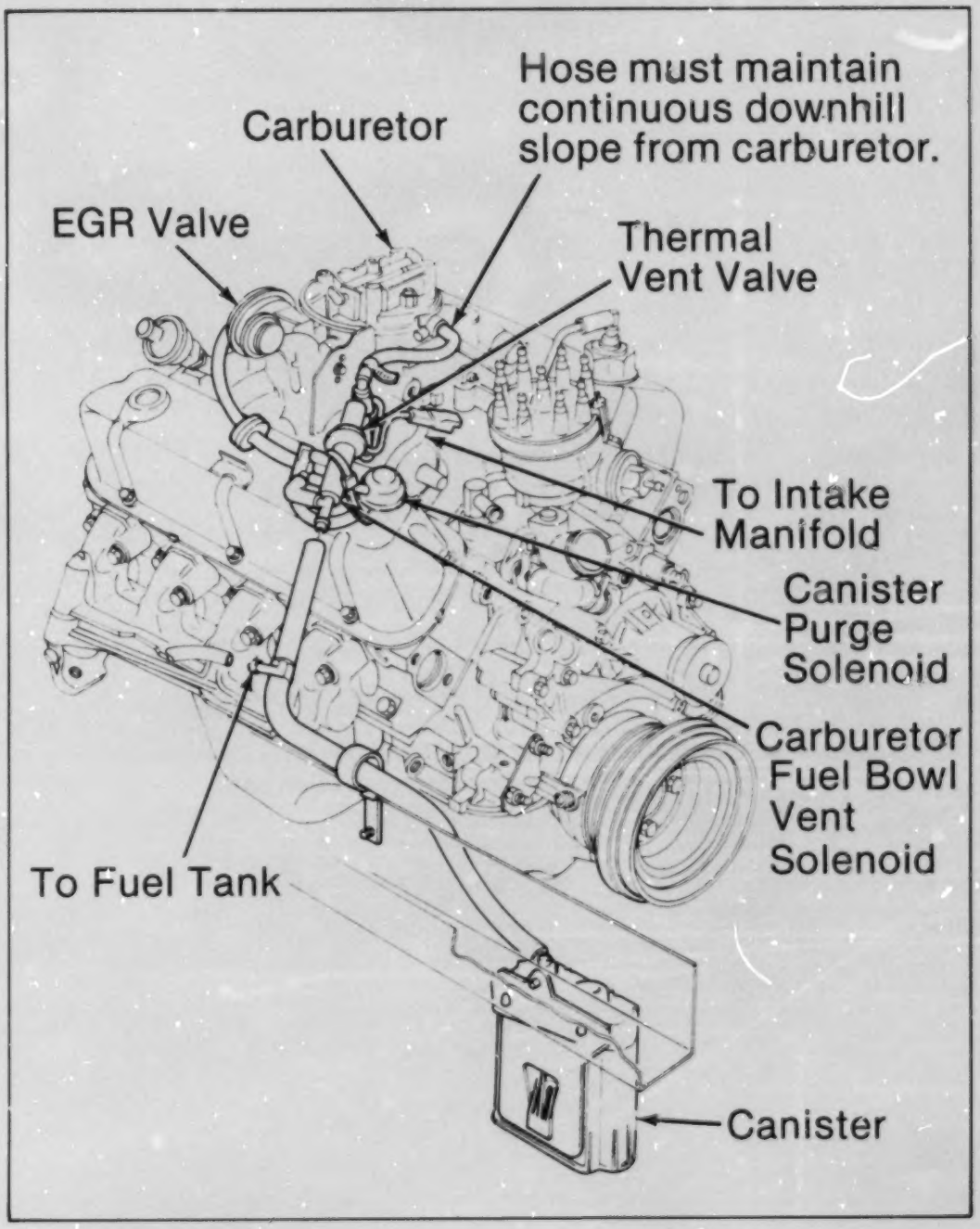
Evaporative Gas Canister Purge
(Continued)



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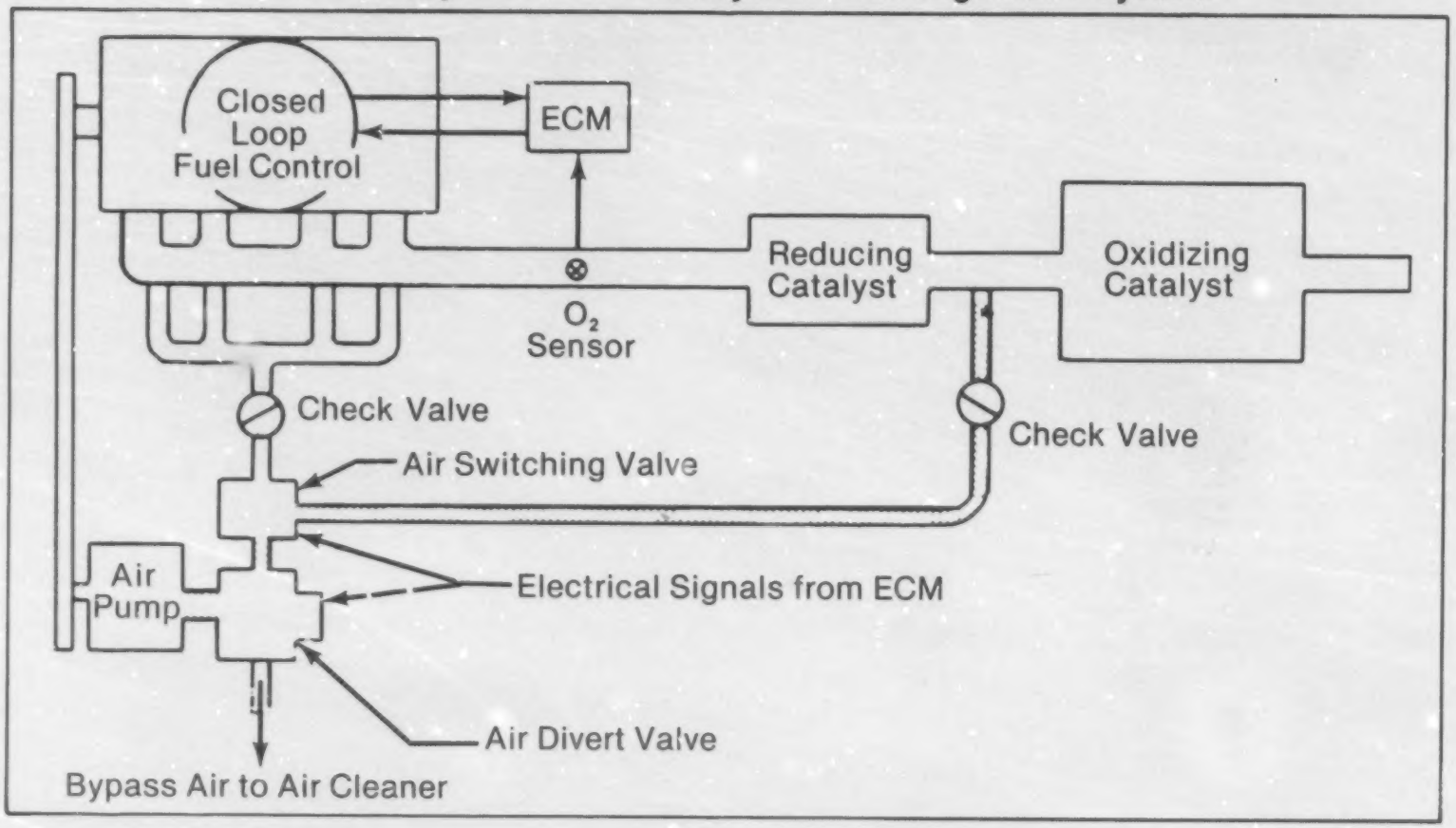
Air Management (GM)

Closed Loop-Dual Bed Catalyst Air Management System



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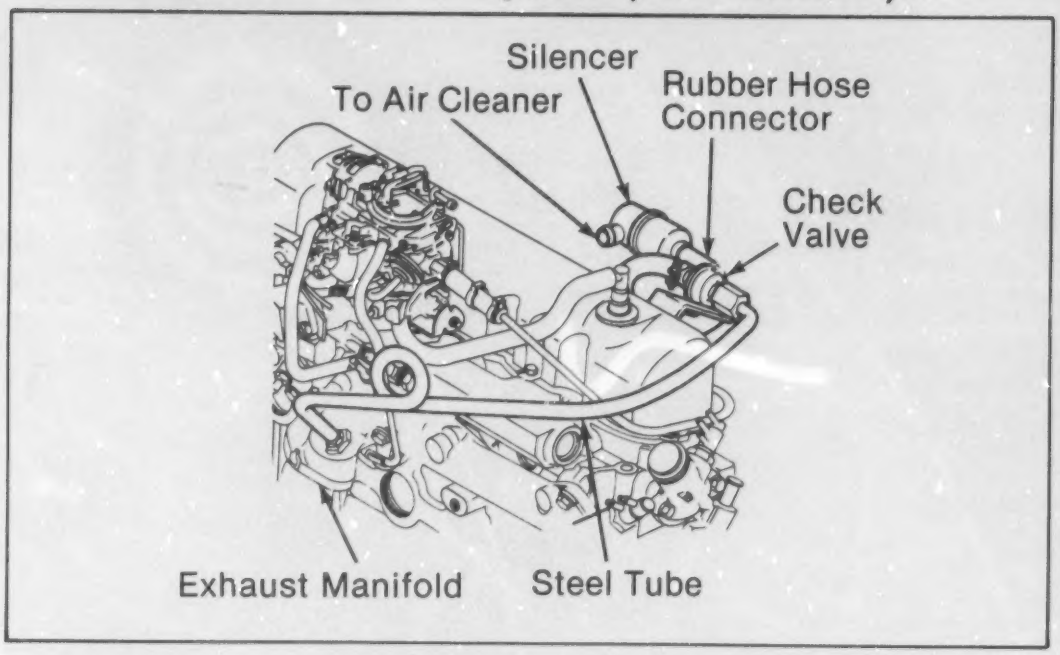
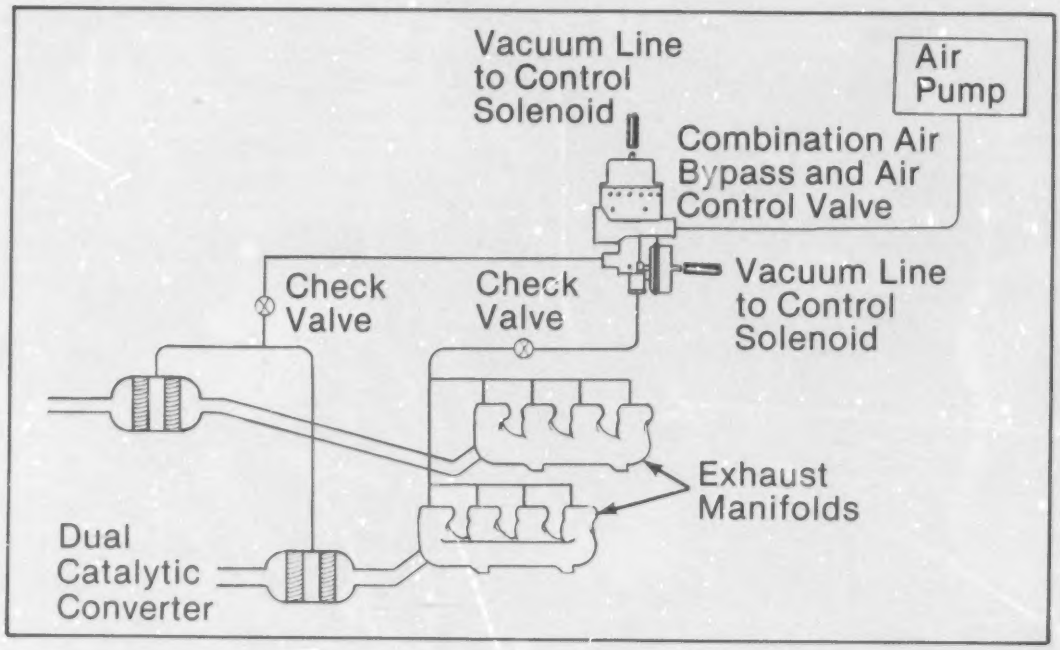
Air Management (Ford)

Typical Pulse Air System (Thermactor II)





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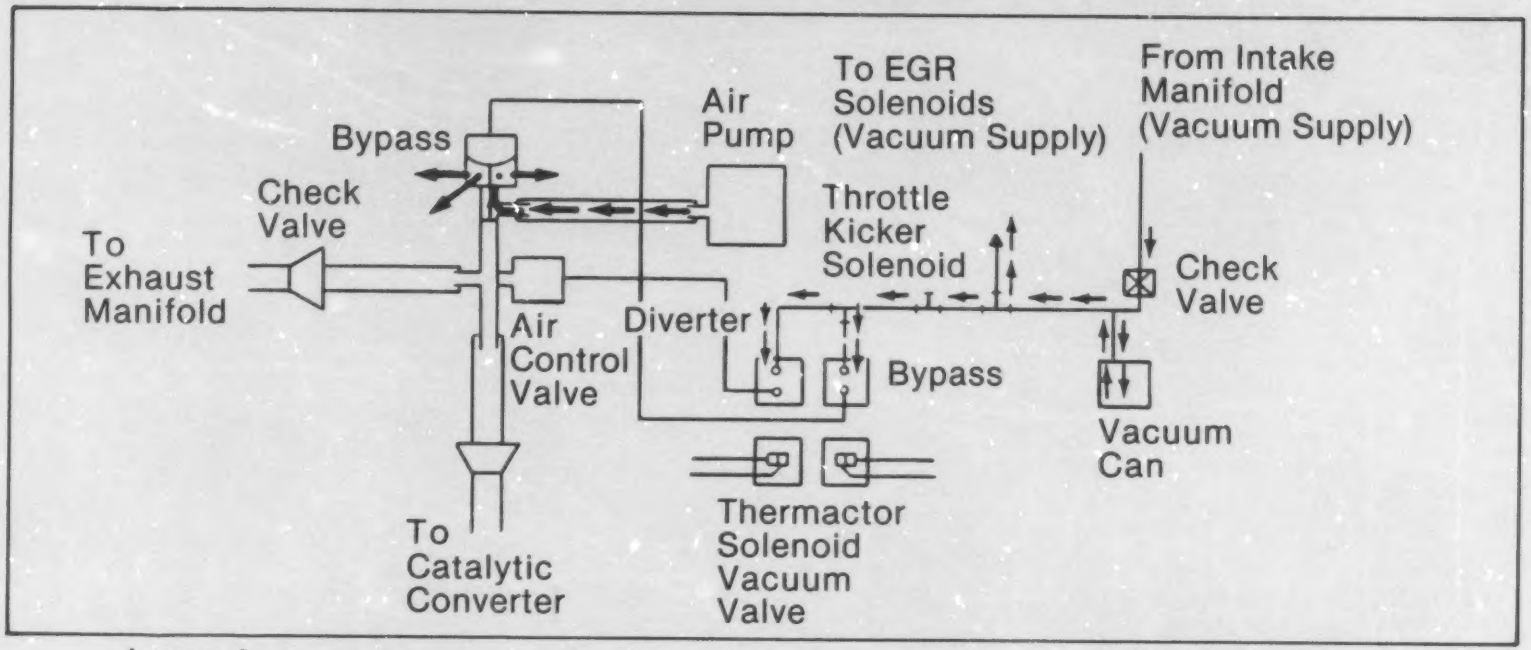
Air Management Paths

Thermactor Air System—Engine Running-Bypass to Atmosphere-Bypass Solenoids Not Activated



Legend

- Air Flow
- Engine Vacuum
- Computer Electrical

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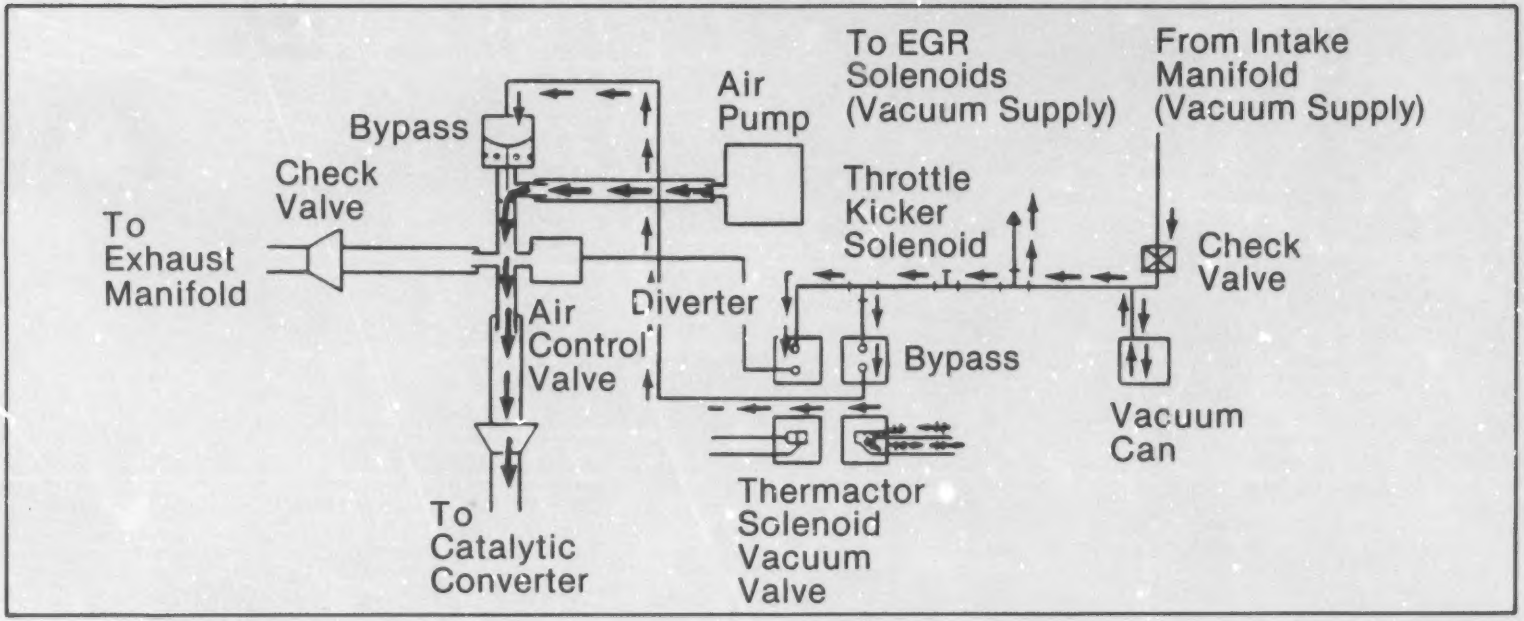
Air Management Paths

(Continued)

Thermactor Air System — Downstream to Catalytic Converter-Bypass Solenoids Activated



Legend

- Air Flow
- Engine Vacuum
- Computer Electrical

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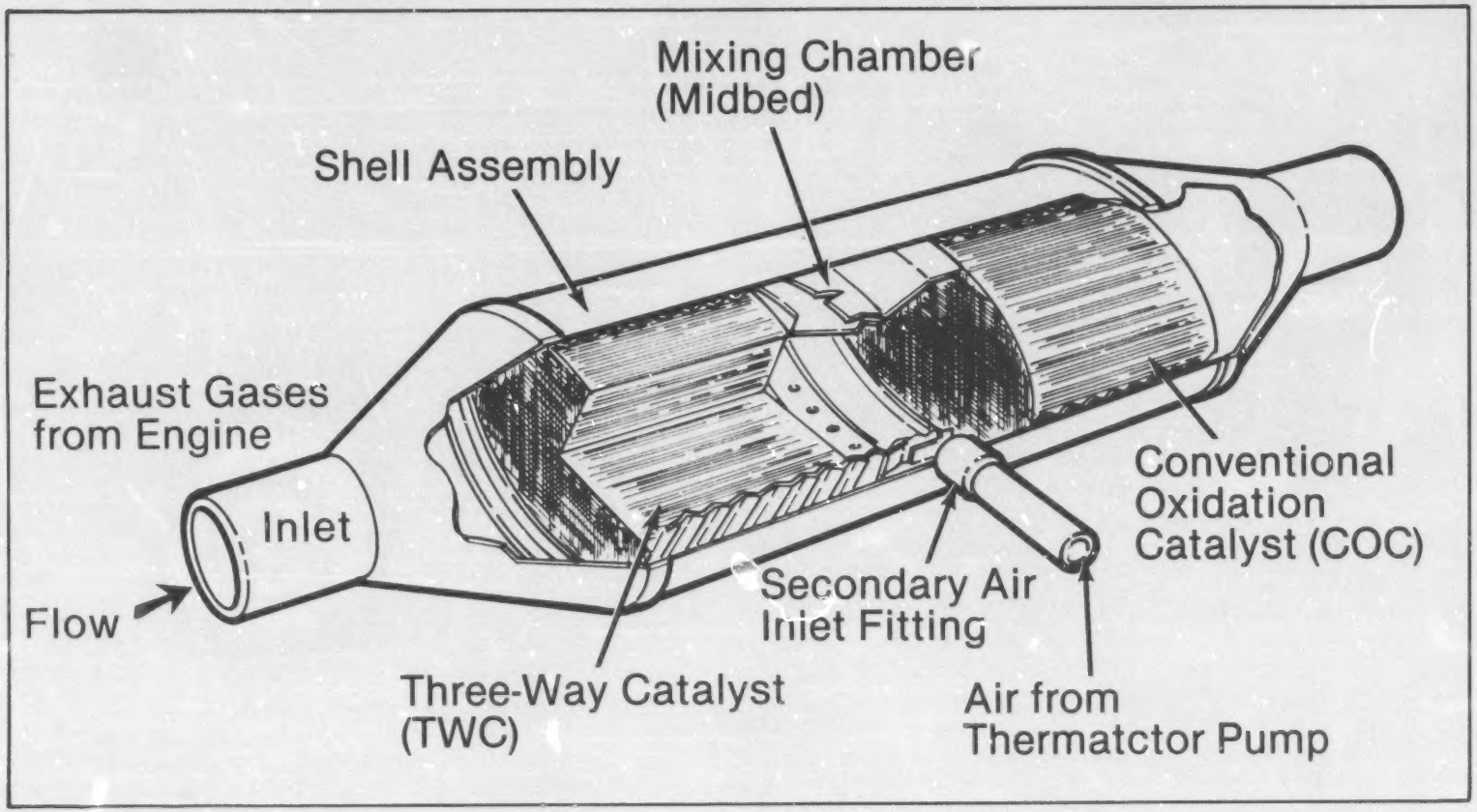
Three-Stage Catalytic Converter



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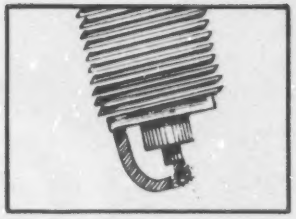
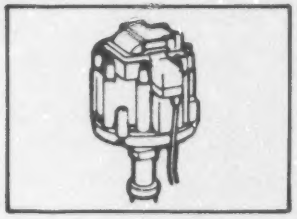
Noncomputer Problems

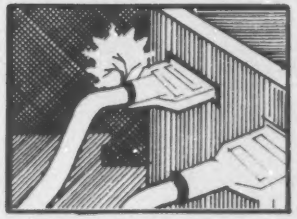


Spark Plugs
- Fouled Plugs
- Burned Plugs
- Wrong Plugs

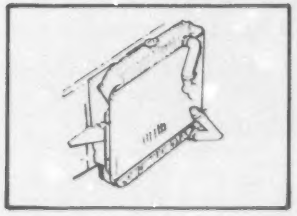
Carburetor
- Incorrect Fuel Level
- Improper Settings or Internal Failure (Metering, Idle, Choke)
- Mechanical Failure (Linkage, Leaky Float)



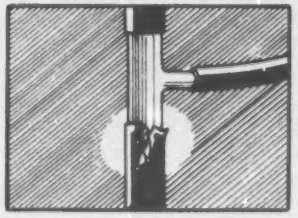
Distributor
- Open or Shorted Circuits
- Wear or Damage (Cracks, Water Damage)



Electrical System
- Loose or Disconnected Wires
- Crimped, Frayed, or Broken Wires
- Shorts Between Wires



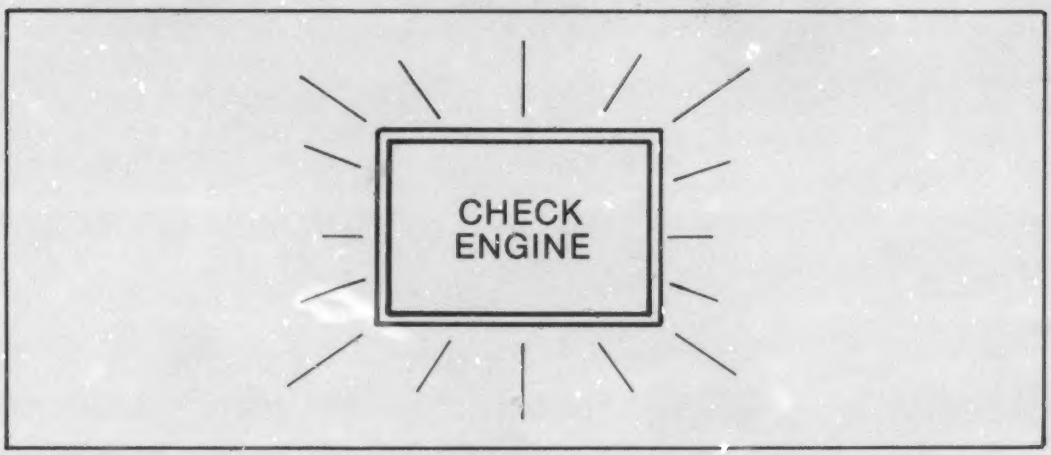
Cooling System
- Damage
- Improper Coolant or Level
- Improper or Malfunctioning Thermostat

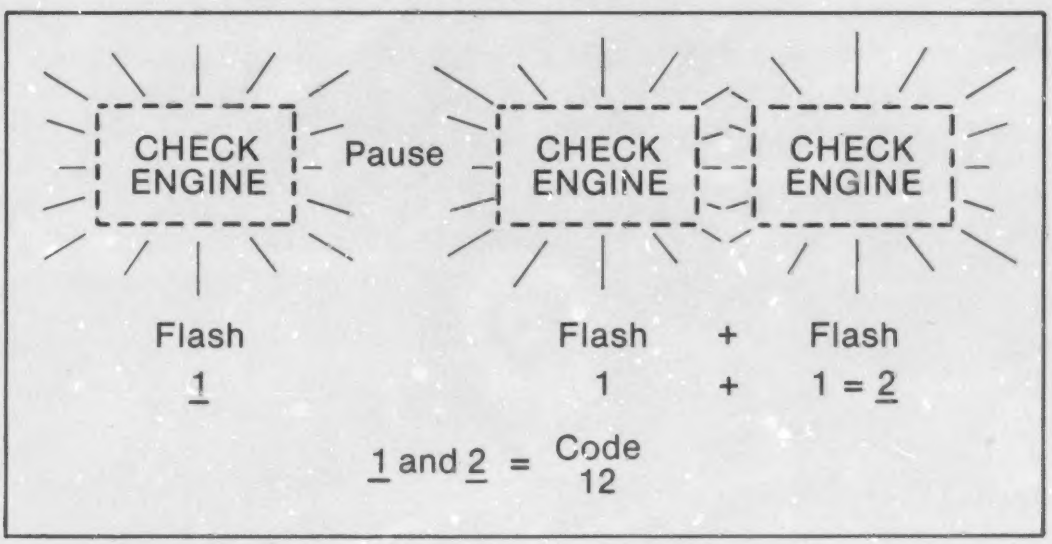


Vacuum System
- Leaky Connections
- Leaks in Lines
- Improperly Routed Lines

"Check Engine" Light

Diagnostic Code Display





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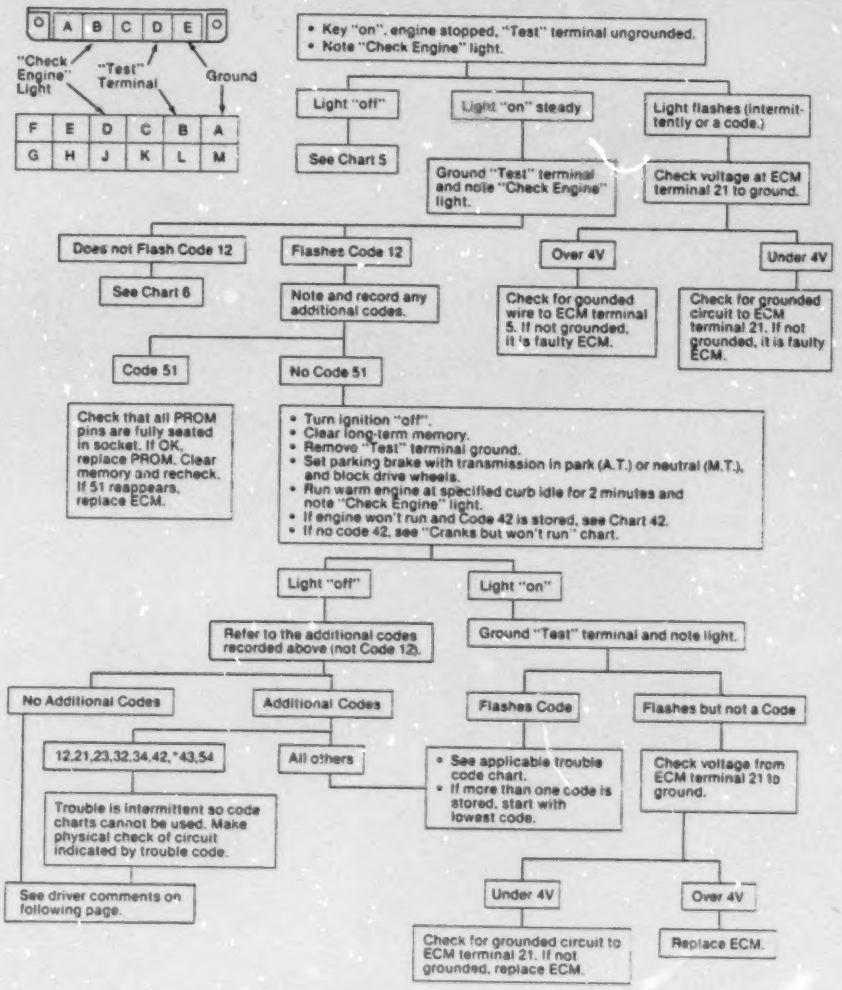
1982 CCC Diagnostic Circuit Check


O A B C D E O
"Check Engine" Light
"Test" Terminal
Ground
F E D C B A
G H J K L M
• Key "on", engine stopped, "Test" terminal ungrounded.
• Note "Check Engine" light.
Light "off"
See Chart 5
Light "on" steady
Ground "Test" terminal and note "Check Engine" light.
Light flashes (intermittently or a code.)
Check voltage at ECM terminal 21 to ground.
Does not Flash Code 12
See Chart 6
Flashes Code 12
Note and record any additional codes.
Over 4V
Check for gounded wire to ECM terminal 5. If not grounded, it is faulty ECM.
Under 4V
Check for grounded circuit to ECM terminal 21. If not grounded, it is faulty ECM.
Code 51
Check that all PROM pins are fully seated in socket. If OK, replace PROM. Clear memory and recheck. If 51 reappears, replace ECM.
No Code 51
• Turn ignition "off".
• Clear long-term memory.
• Remove "Test" terminal ground.
• Set parking brake with transmission in park (A.T.) or neutral (M.T.), and block drive wheels.
• Run warm engine at specified curb idle for 2 minutes and note "Check Engine" light.
• If engine won't run and Code 42 is stored, see Chart 42.
• If no code 42, see "Cranks but won't run" chart.
Light "off"
Refer to the additional codes recorded above (not Code 12).
No Additional Codes
12,21,23,32,34,42,*43,54
Trouble is intermittent so code charts cannot be used. Make physical check of circuit indicated by trouble code.
See driver comments on following page.
Additional Codes
All others
Light "on"
Ground "Test" terminal and note light.
Flashes Code
• See applicable trouble code chart.
• If more than one code is stored, start with lowest code.
Flashes but not a Code
Check voltage from ECM terminal 21 to ground.
Under 4V
Check for grounded circuit to ECM terminal 21. If not grounded, replace ECM.
Over 4V
Replace ECM.

Before replacing an ECM, always check PROM for correct application and installation. Also, remove terminal(s) from ECM connector for circuit involved, clean terminal contact and expand it slightly to increase contact pressure and recheck to see if problem is corrected. In case of repeat ECM failure, check for a shorted solenoid or relay controlled by the ECM.

The system performance check should be performed after any repairs to the system have been made.

*It is possible to set a false Code 42 on starting, but the "Check Engine" light will not be "on." No corrective action is necessary.

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Sample Trouble Code Identification (GM)

The "CHECK ENGINE" light will only be "ON" if the malfunction exists under the conditions listed below. It takes up to five seconds minimum for the light to come on when a problem occurs. If the malfunction clears, the light will go out and a trouble code will be set in the ECM. Code 12 does not store in memory. If the light comes "on" intermittently, but no code is stored, go to the "Driver Comments" section. Any codes stored will be erased if no problem reoccurs within 50 engine starts.

The trouble codes indicate problems as follows:

TROUBLE CODE 12 No distributor reference pulses to the ECM. This code is not stored in memory and will only flash while the fault is present.

TROUBLE CODE 13 Oxygen sensor circuit - The engine must run up to five minutes at part throttle, under road load, before this code will set.

TROUBLE CODE 14 Shorted coolant sensor circuit — The engine must run up to five minutes before this code will set.

TROUBLE CODE 15 Open coolant sensor circuit - The engine must run up to five minutes before this code will set.

TROUBLE CODE 21 Throttle position sensor circuit — The engine must run up to 25 seconds, at specified curb idle speed, before this code will set.

TROUBLE CODE 23 Open or grounded M/C solenoid circuit.

TROUBLE CODE 24 Vehicle speed sensor (VSS) circuit - The car must operate up to five minutes at road speed before this code will set.

TROUBLE CODE 32 Barometric pressure sensor (BARO) circuit low, or altitude compensator low on J-Car.

TROUBLE CODE 34 Manifold absolute pressure (MAP) or vacuum sensor circuit — The engine must run up to five minutes, at specified curb idle speed, before this code will set.

TROUBLE CODE 35 Idle speed control (ISC) switch circuit shorted. (Over 50% throttle for over 2 seconds.)

TROUBLE CODE 41 No distributor reference pulses to the ECM at specified engine vacuum. This code will store in memory.

TROUBLE CODE 42 Electronic spark timing (EST) bypass circuit or EST circuit grounded or open.

TROUBLE CODE 43 ESC retard signal for too long; causes a retard in EST signal.

TROUBLE CODE 44 Lean exhaust indication - The engine must run up to five minutes, in closed loop, at part throttle and road load before this code will set.

TROUBLE CODE 44 & 55 (At same time) - Faulty oxygen sensor circuit.

TROUBLE CODE 45 Rich exhaust indication - The engine must run up to five minutes, in closed loop, at part throttle and road load before this code will set.

TROUBLE CODE 51 Faulty calibration unit (PROM) or installation. It takes up to 30 seconds before this code will set.

TROUBLE CODE 54 Shorted M/C solenoid circuit and/or faulty ECM.

TROUBLE CODE 55 Grounded V reference (terminal "21"), faulty oxygen sensor or ECM.

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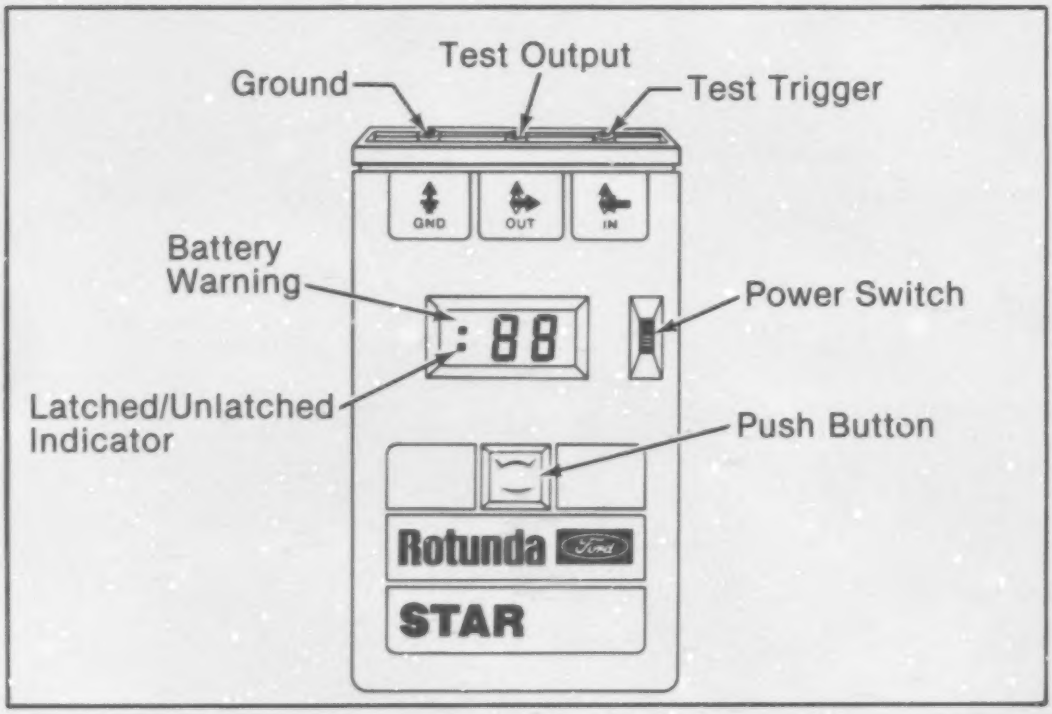
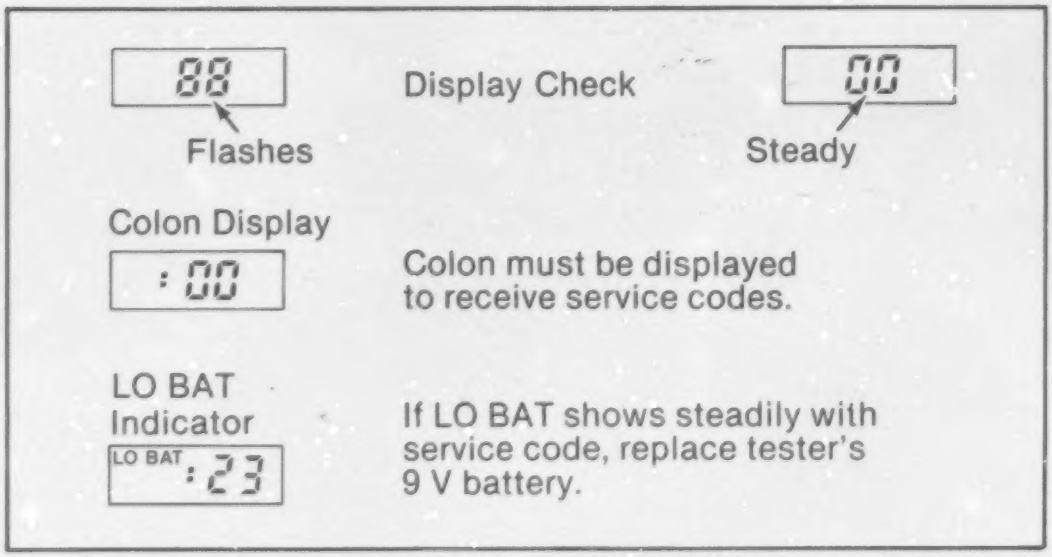
Self-Test Automatic Readout (STAR) Display and Hookup





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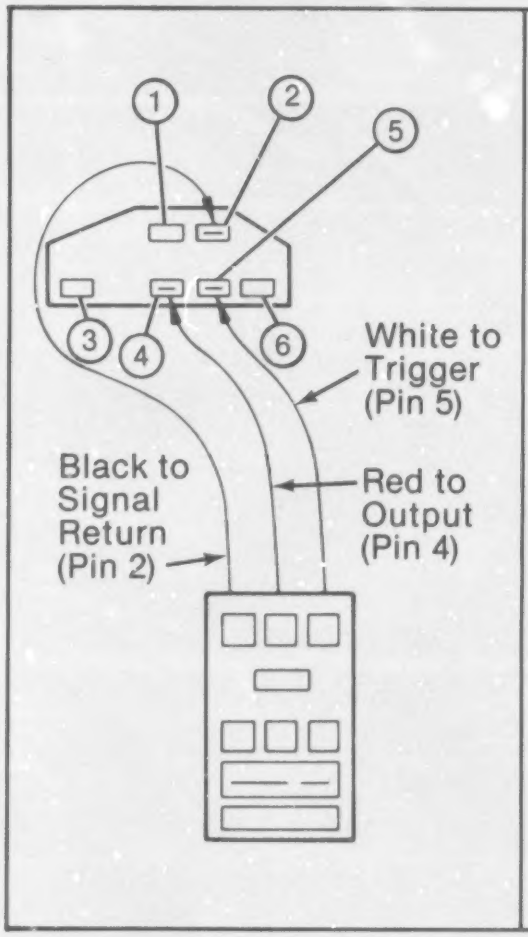
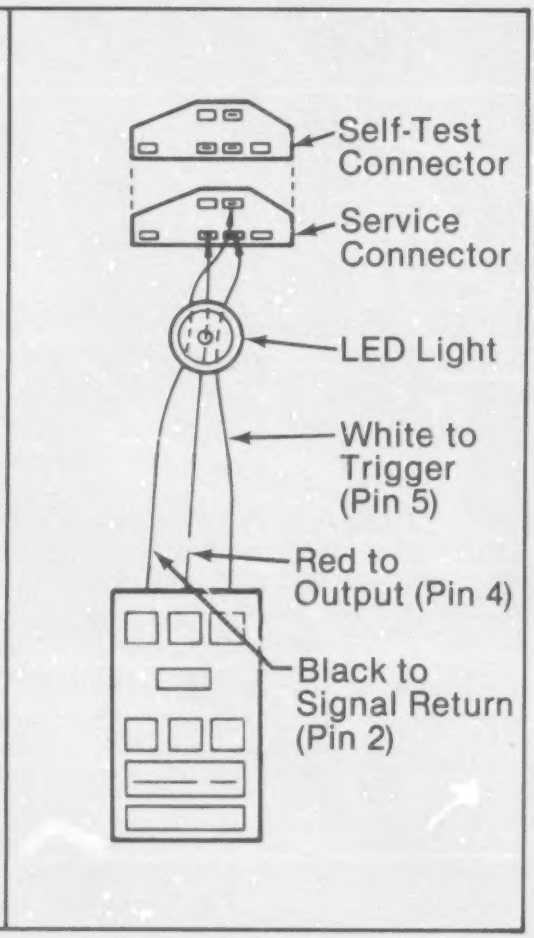
Self-Test Automatic Readout (STAR) Display and Hookup

(Continued)

Star Device Hookup (Without Adapter Cable Assembly)



Star Hookup (With Adapter Cable Assembly)



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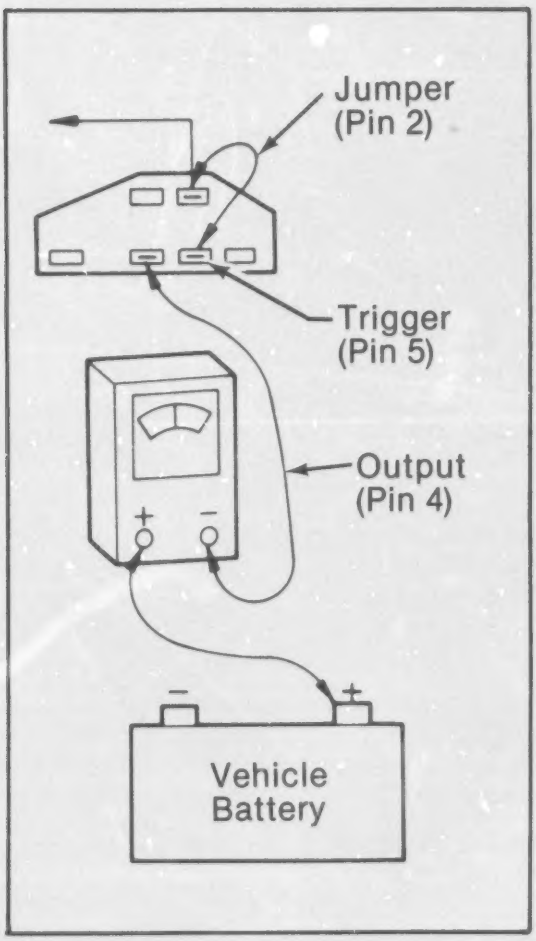
Jumper and Voltmeter Hookup and Reading



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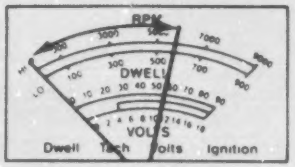
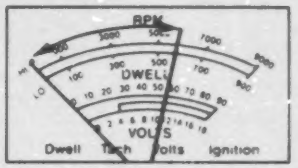
Jumper and Voltmeter Hookup and Reading
(Continued)

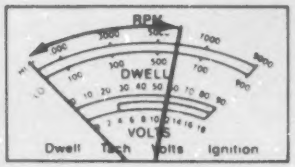


1 Needle Pulse (Sweep) + 

1 Needle Pulse (Sweep) = 2 Needle Pulses (Sweeps) for First Digit

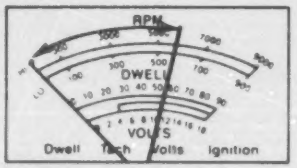
Two-Second Pause Between Digits

: 23 Service Code



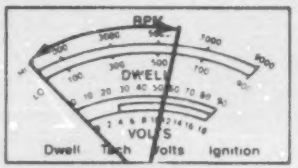
1 Needle Pulse (Sweep) for ½ Second

½ Second Pause



+ 1 Needle Pulse (Sweep) for ½ Second

½ Second Pause



+ 1 Needle Pulse (Sweep) for ½ Second = 3 Needle Pulses (Sweeps) for Second Digit

Four-Second Pause Between Service Codes, When More Than One Code Is Indicated

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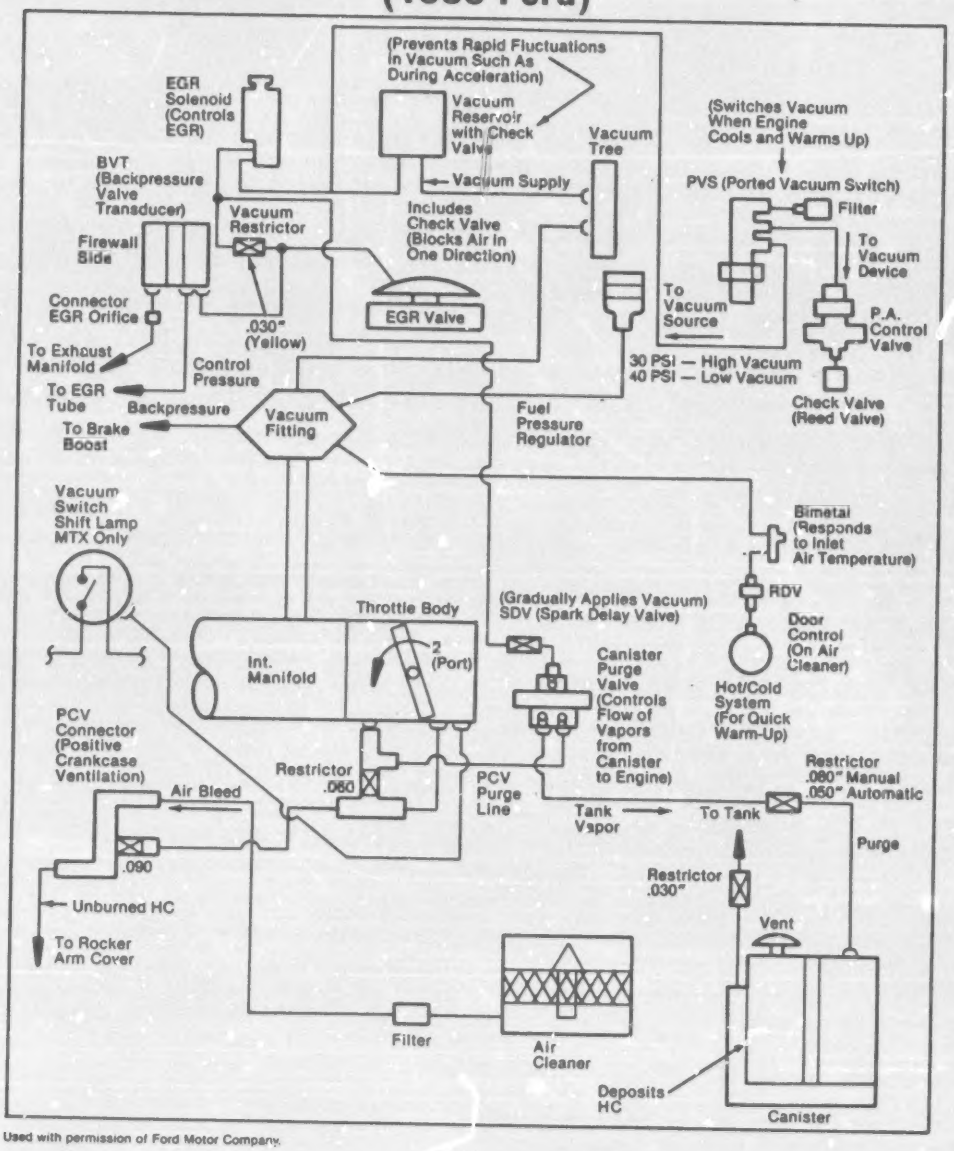
Vacuum Diagram (1983 Ford)



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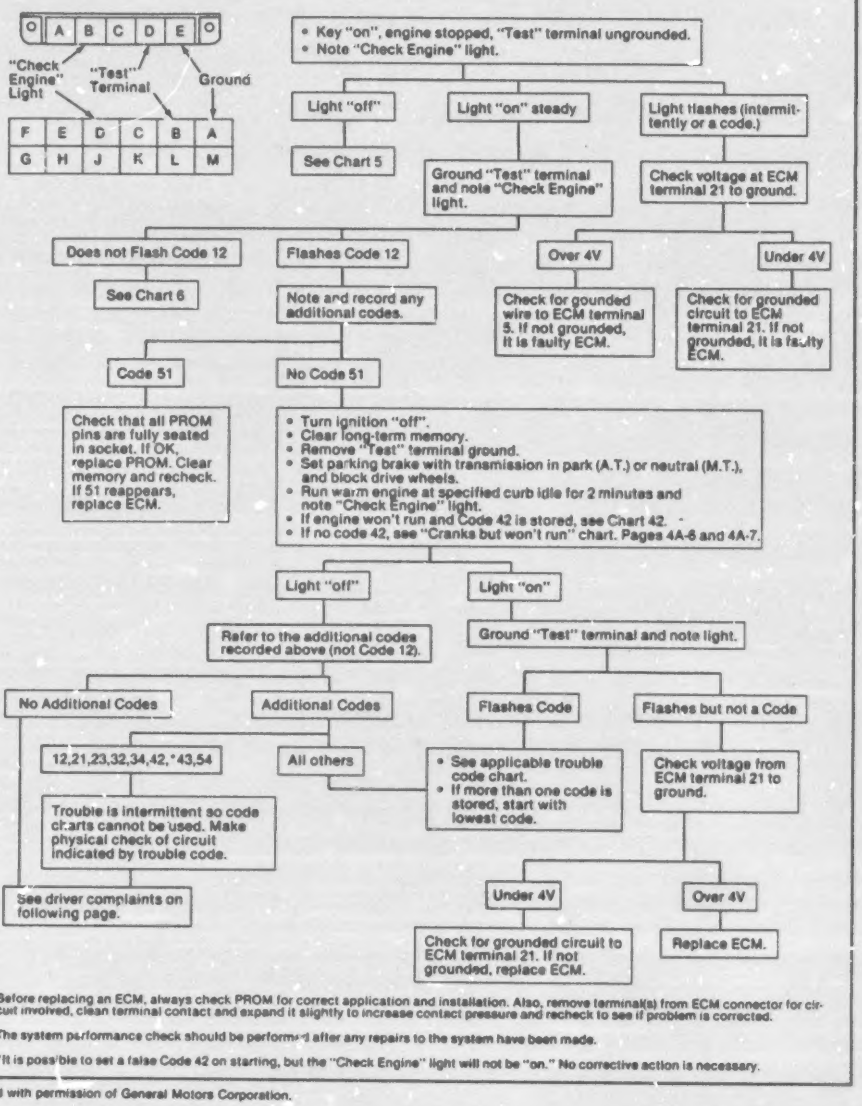
Quick-Test Chart (GM)

1982 CCC

Diagnostic Circuit Check


O A B C D E O
"Check Engine" Light
"Test" Terminal
Ground
F E D C B A
G H J K L M
• Key "on", engine stopped, "Test" terminal ungrounded.
• Note "Check Engine" light.
Light "off"
Light "on" steady
Light flashes (intermittently or a code.)
See Chart 5
Ground "Test" terminal and note "Check Engine" light.
Check voltage at ECM terminal 21 to ground.
Does not Flash Code 12
Flashes Code 12
Over 4V
Under 4V
See Chart 6
Note and record any additional codes.
Check for gounded wire to ECM terminal 5. If not grounded, it is faulty ECM.
Check for grounded circuit to ECM terminal 21. If not grounded, it is faulty ECM.
Code 51
No Code 51
Check that all PROM pins are fully seated in socket. If OK, replace PROM. Clear memory and recheck. If 51 reappears, replace ECM.
• Turn ignition "off".
• Clear long-term memory.
• Remove "Test" terminal ground.
• Set parking brake with transmission in park (A.T.) or neutral (M.T.), and block drive wheels.
• Run warm engine at specified curb idle for 2 minutes and note "Check Engine" light.
• If engine won't run and Code 42 is stored, see Chart 42.
• If no code 42, see "Cranks but won't run" chart. Pages 4A-6 and 4A-7.
Light "off"
Light "on"
Refer to the additional codes recorded above (not Code 12).
Ground "Test" terminal and note light.
No Additional Codes
Additional Codes
Flashes Code
Flashes but not a Code
12,21,23,32,34,42,*43,54
All others
• See applicable trouble code chart.
• If more than one code is stored, start with lowest code.
Check voltage from ECM terminal 21 to ground.
Trouble is intermittent so code charts cannot be used. Make physical check of circuit indicated by trouble code.
See driver complaints on following page.
Under 4V
Over 4V
Check for grounded circuit to ECM terminal 21. If not grounded, replace ECM.
Replace ECM.

Before replacing an ECM, always check PROM for correct application and installation. Also, remove terminal(s) from ECM connector for circuit involved, clean terminal contact and expand it slightly to increase contact pressure and recheck to see if problem is corrected.

The system performance check should be performed after any repairs to the system have been made.

*It is possible to set a false Code 42 on starting, but the "Check Engine" light will not be "on." No corrective action is necessary.

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Quick-Test Chart (Ford)

Test Step	
1	**Pre-Check Procedures and Vehicle Pre-Start Preparation**

Before hooking up the equipment to diagnose the EEC system, make the following pre-checks:

1. Remove the air cleaner assembly, and reinstall it after visual inspection is complete.
2. Check* all engine vacuum hoses for:
   - Proper routing per vacuum schematic,
   - Proper connections to fittings,
   - Broken, cracked, pinched hoses or fittings.
3. Check* the EEC system wiring harness electrical connections for:
   - Proper connections,
   - Loose or detached connectors,
   - Corrosion,
   - Partially broken or frayed wires at connectors,
   - Shorting between wires,
   - Broken or detached wires,
   - Terminals not completely seated in connectors,
   - And proper routing and lay of harness.
4. Check ECA, sensors, actuators, and pulse ring lobes for physical damage and the CP sensor for proper seating.
5. Perform all safety steps required to start and run a vehicle for servicing.
6. Turn OFF all vehicle electrical loads, such as the radio, lights, air conditioner, etc.
7. Be sure vehicle doors are shut whenever readings are made.
8. Check radiator cold fill level, then start engine and idle until the upper radiator hose is hot and pressurized and the throttle is off fast idle. (NOTE: Observe the cooling system for normal operation during this time, i.e., long warm-up time, overtemp, etc. and if necessary correct.)

*See wiring and vacuum diagrams and location diagram.

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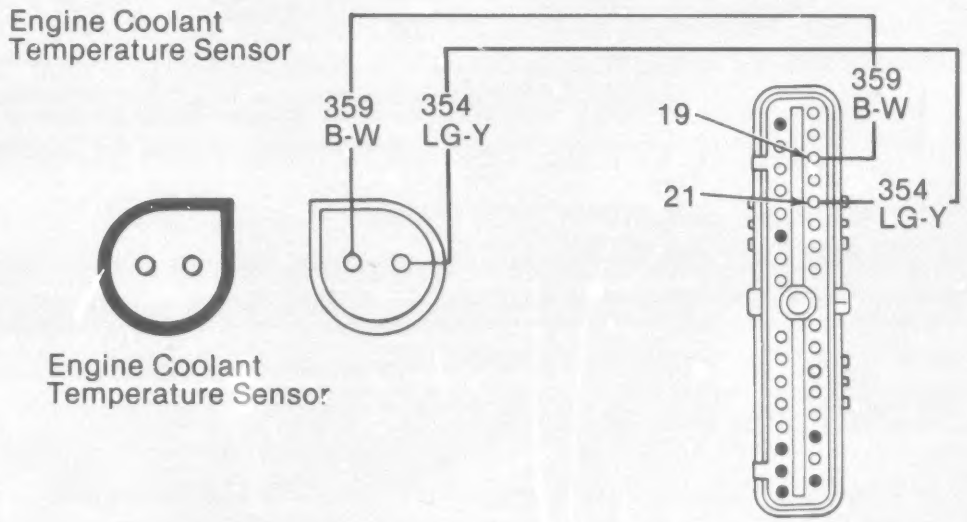
Engine Coolant Temperature Pinpoint Test (Ford)



STOP-WARNING

You may have reached this point because of a fault in a non-EEC System and/or component. To prevent the replacement of good components, be aware that the following non-EEC areas may be at fault:

- Coolant Level
- Oil Level
- Blocked or Obstructed Air Flow
- Engine Not at Normal Operating Temperature

This Pinpoint Test is intended to diagnose only the following:

- ECT Sensor
- Harness Circuits 354 and 359
- Processor Assembly
- Calibration Assembly

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Engine Coolant Temperature Pinpoint Test (Ford)
(Continued)

Test Step	Result ►	Action to Take
E1 Check Engine Operating Temperature NOTE: This step is performed when the ECT sensor and circuit indicate that the engine coolant temperature is not within the normal operating range of a hot engine. • What does the operating temperature of the engine appear to be?	Appears To Be At Normal Operating Temperature ►	GO to E2
	Overheated ►	GO to Routine No. 217
	Less Than Normal Operating Temperature ►	GO to Routine No. 216
E2 Start Engine to Bring ECT Within Limits • Tester to A-5 • DVOM Switch to Test • Start Engine • Check that upper radiator hose is hot and pressured. • Increase rpm to attempt bringing ECT sensor reading between 0.75 and 2.60 volts (5-10 minutes).	DVOM Reading: Between 0.75V and 2.60V ►	Repeat Quick Test
	Under 0.75V ►	GO to E3
	More than 2.60V ►	GO to E5
E3 Check Harness for Shorts • Turn key to ON. • Switch tester to A-5. • Disconnect harness from ECT sensor. 	DVOM Reading: More Than 8.00V ►	Check the engine for overheating, and let cool down. If this fails to correct the problem, replace the sensor and retest.
	Less Than 8.00V ►	GO to E4

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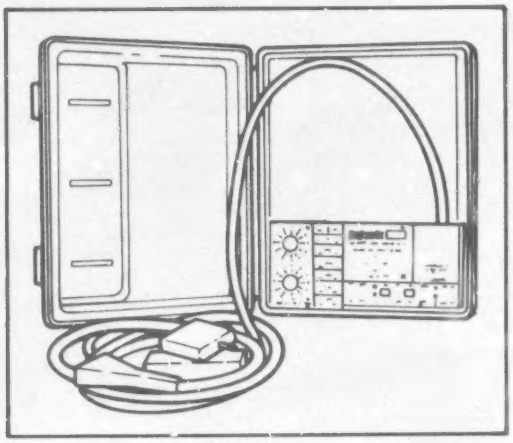
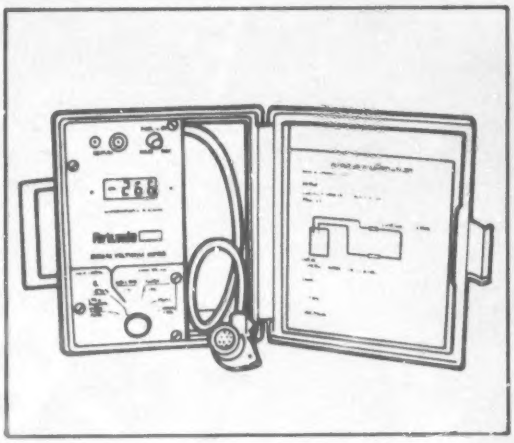
Special Test Equipment

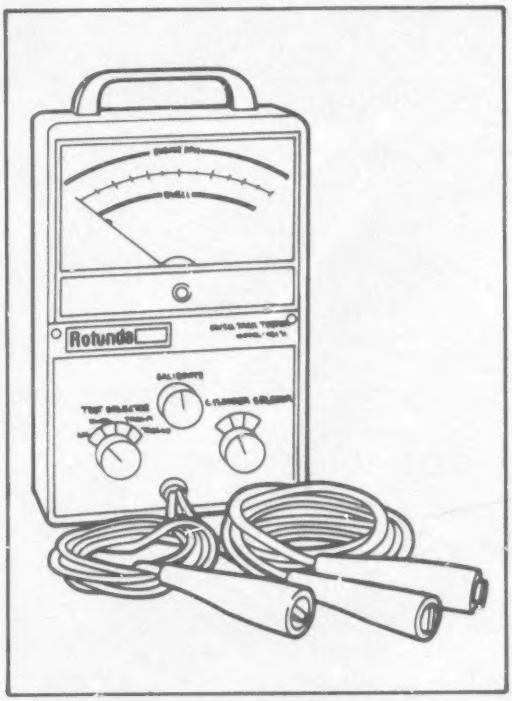
Electronic Circuitry Tester



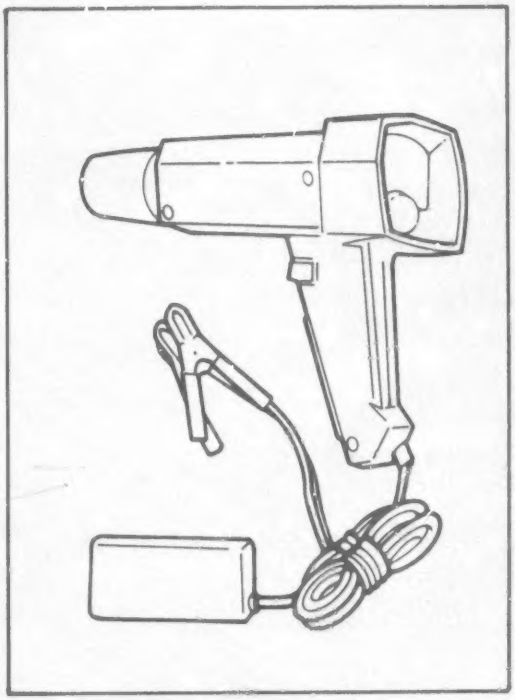
Digital Voltohmmeter



Tachometer



Timing Light



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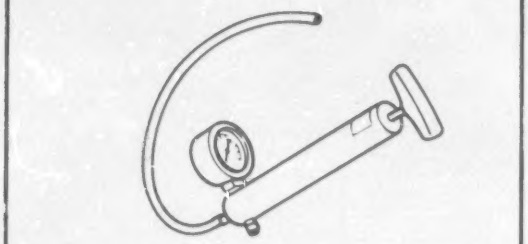
Special Test Equipment
(Continued)

Vacuum Pump



Spark Tester

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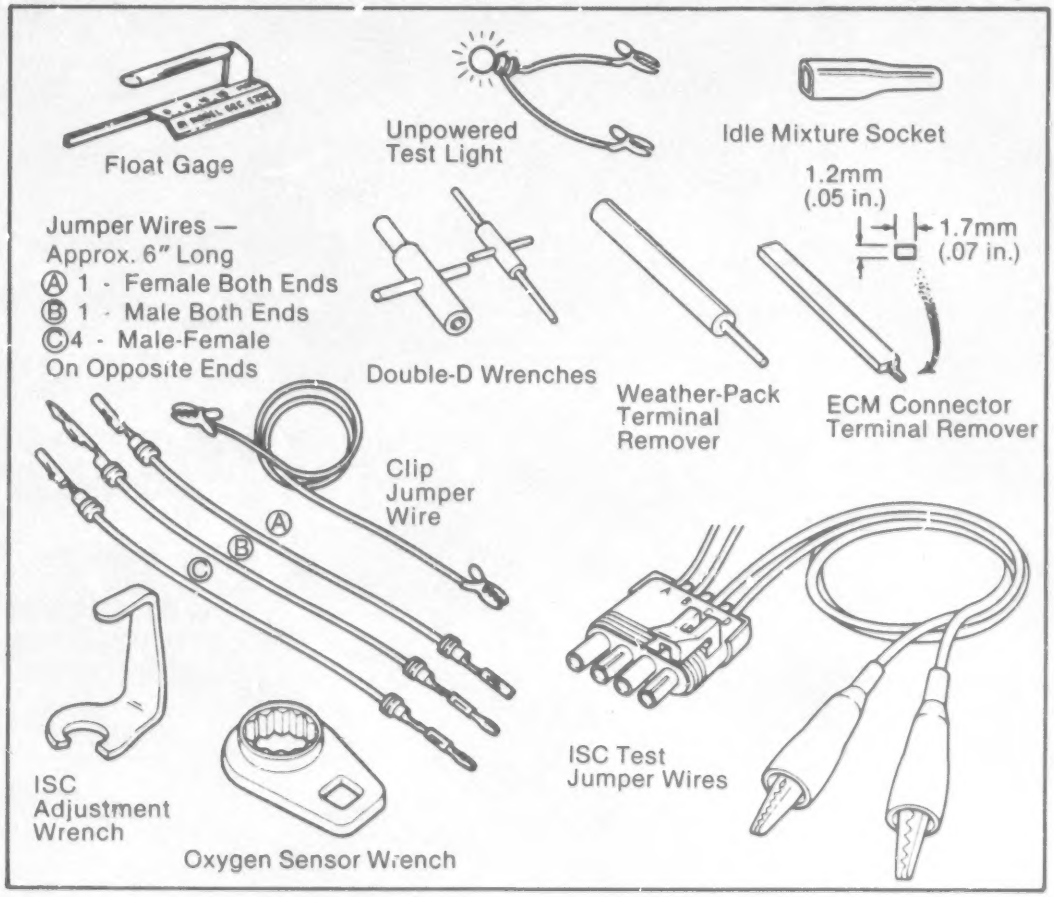
Typical Miscellaneous System Tools (GM CCC System)



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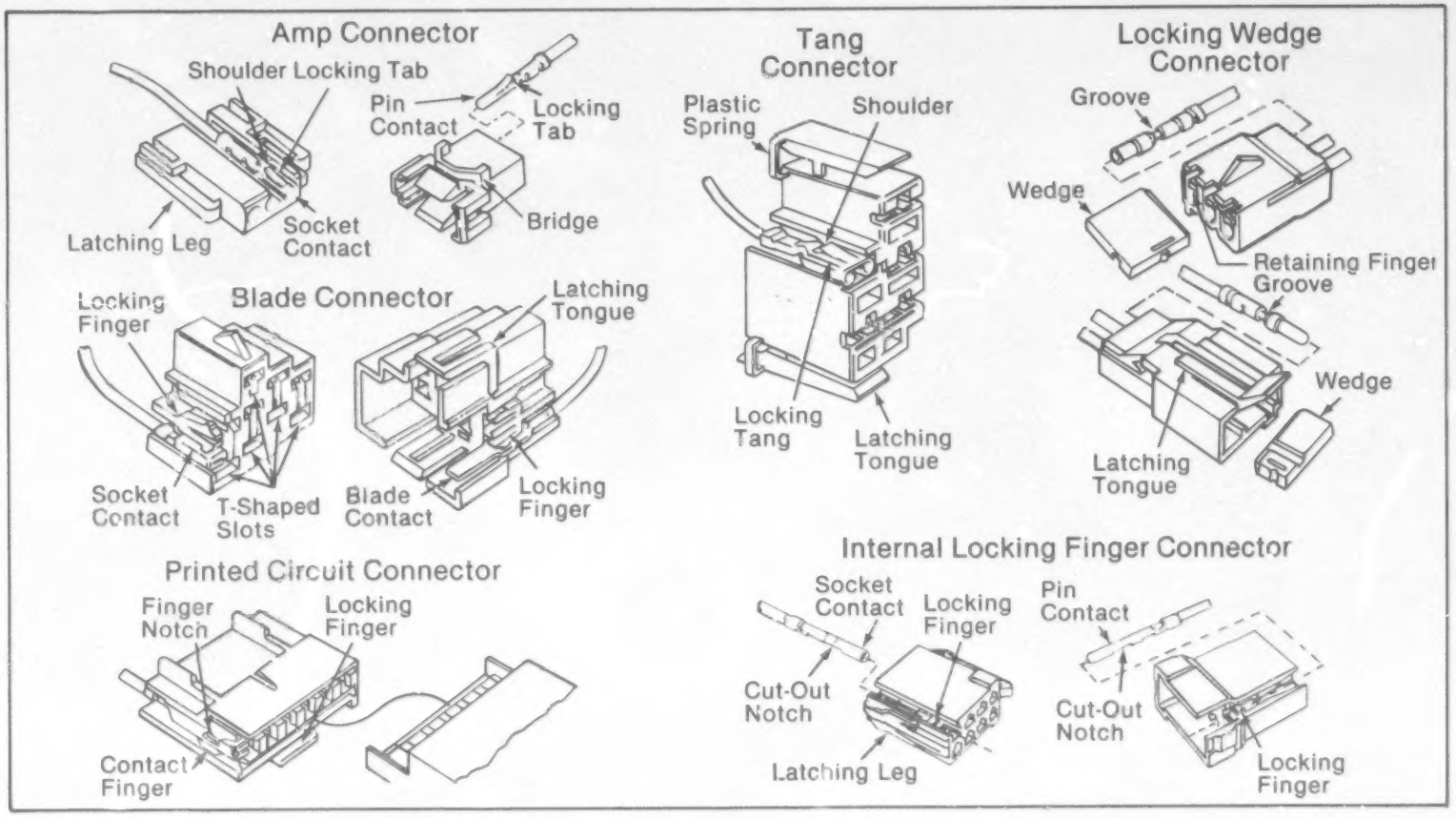
Electrical Connectors

Typical Designs for Hard-Shell Connectors



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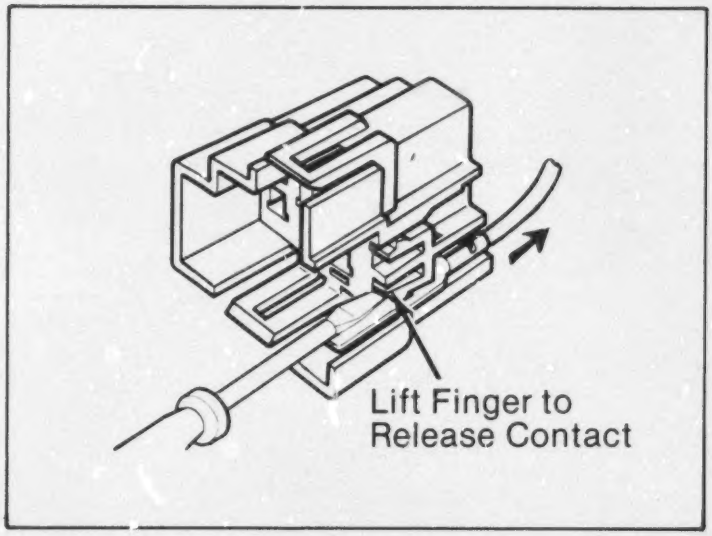
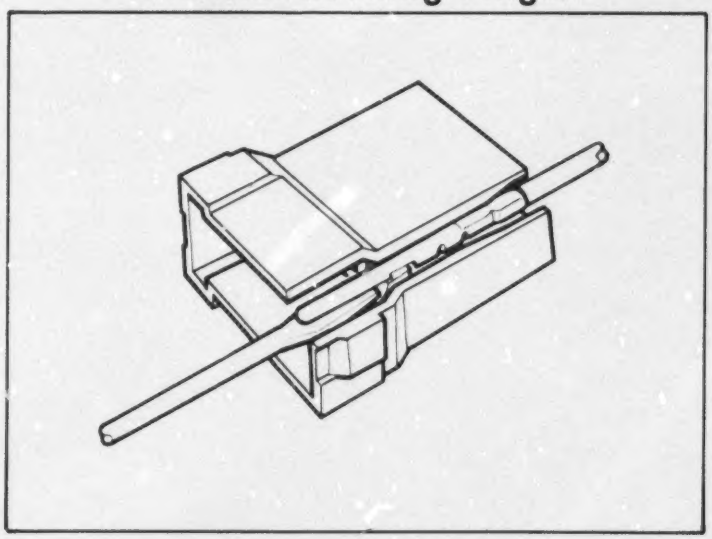
Electrical Connectors
(Continued)

Removal of Blade-Type Connector



Removal of Pin-Type Connector with Internal-Locking Finger



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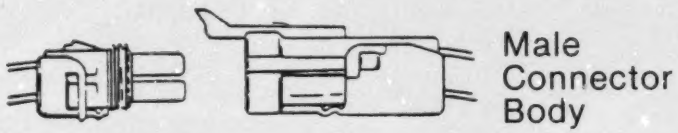
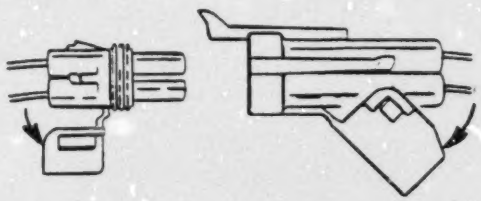
Weather-Pack Terminal

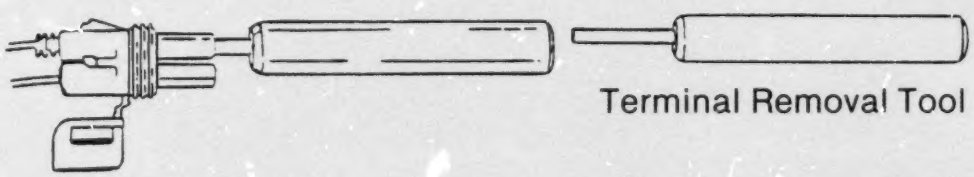
Repair Procedure



1. Open secondary lock hinge on connector.

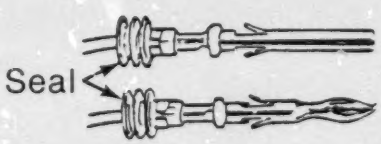


2. Remove terminals using special tool J-28742.



3. Cut wire immediately behind cable seal.

4. Slip new cable seal onto wire (in direction shown) and strip 5.0 mm (.2") of insulation from wire. Position cable seal as shown.



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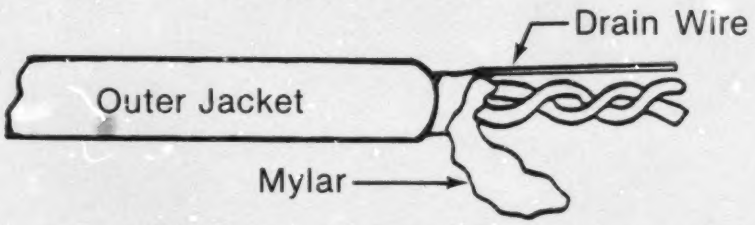
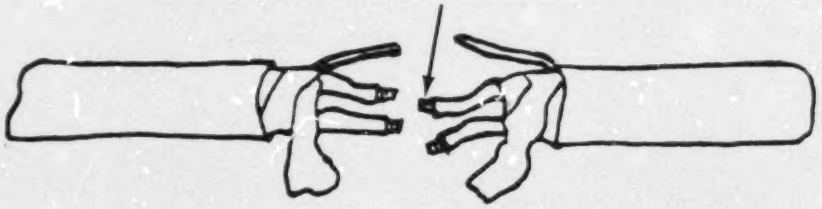
Wire Splicing

Twisted/Shielded Cable

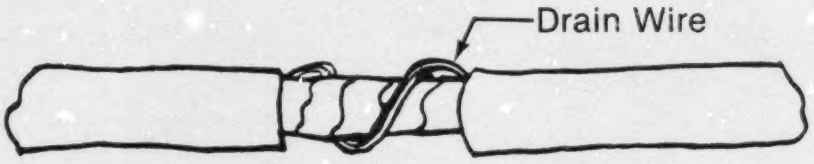
1. Remove outer jacket.
2. Unwrap aluminum/mylar tape. Do not remove mylar.



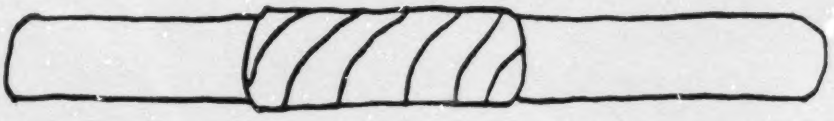
3. Untwist conductors. Strip insulation as necessary.



4. Splice wires using splice clips and rosin core solder. Wrap each splice to insulate.



5. Wrap with mylar and drain (uninsulated) wire.
6. Tape over whole bundle to secure as before.



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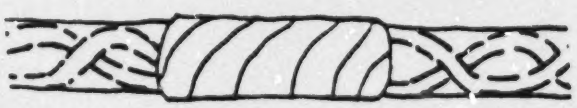
Wire Splicing
(Continued)

Twisted Leads

1. Locate damaged wire.
2. Remove insulation as required.

3. Splice two wires together using splice clips and rosin core solder.

4. Cover splice with tape to insulate from other wires.
5. Retwist as before and tape with electrical tape to hold in place.



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AUTOMOTIVE COMPUTER UNITS
AUTO MECHANICS SUPPLEMENT

INFORMATION SHEET

I. Terms and definitions

A. Computer — Electronic device used to store information that can be compared to data on input signals in order to determine the correct output signals

(NOTE: Manufacturers use various terms for their automotive computers, including *electronic control module* [ECM], *microprocessor unit* [MCU], *electronic control assembly* [ECA], and *central processing unit* [CPU].)

B. ROM — Read-only memory; portion of computer memory that contains information used in system operation that is not limited to vehicle in which computer is installed

EXAMPLE: The lowest code number is given first.

C. PROM — Programmable read-only memory; portion of computer memory that contains identifying characteristics of vehicle

EXAMPLES: Engine size, vehicle weight, type of transmission, final drive gear ratio

(NOTE: The PROM matches the computer to the vehicle so that the computer will have the information needed to tailor engine performance to the capabilities of that particular vehicle.)

D. RAM — Random access memory; portion of computer memory used for temporary storage of such information as trouble codes

E. Ambient air — Atmosphere of vehicle's environment

F. Early fuel evaporation — System that enhances atomization by using exhaust gases to warm fuel entering the carburetor

G. Atomization — Process of breaking a liquid into a fine mist

H. Canister purge — Transferal of stored fuel vapors from charcoal filter storage canister to intake manifold

I. Light-emitting diode (LED) — Electronic device capable of producing light in the presence of low-level electrical currents

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II. Purpose of automotive computer systems — To provide more accurate control of fuel-air mixtures, spark timing control, and air supplies to improve engine performance, fuel economy, and emissions control under all driving conditions

III. Major functions of automotive computer systems (Figure 1)

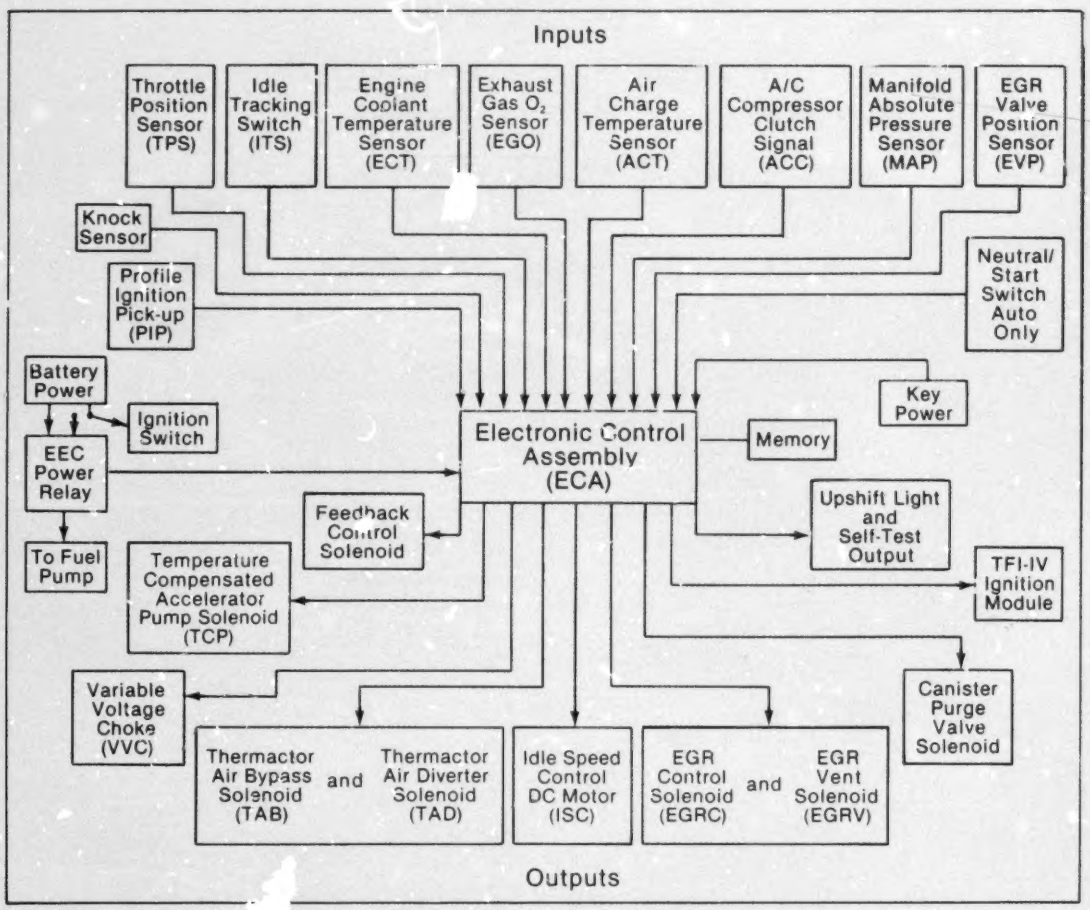
A. Input (sensing)

B. Output (actuation)

C. Memory (storage)

EXAMPLE:

FIGURE 1



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IV. Functions and operations of major sensor components in an automotive computer system

(NOTE: Other sensors may be used, but the following are the most common.)

A. Oxygen sensor (Figure 2)

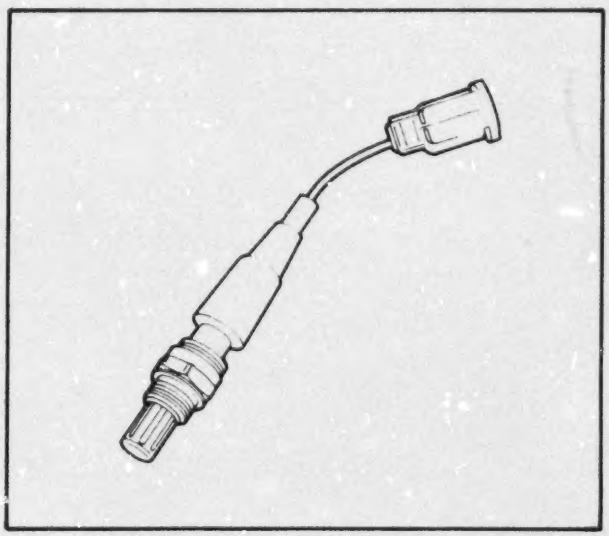
1. Compares oxygen content of exhaust gases to that of ambient air

2. Sends lower voltage signal to computer if exhaust gases are high in oxygen, indicating that air-fuel mixture is too lean in gasoline

3. Sends higher voltage signal to computer if exhaust gases are low in oxygen, indicating that air-fuel mixture is too rich in gasoline

EXAMPLE:

FIGURE 2



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B. Engine coolant temperature sensor (Figure 3)

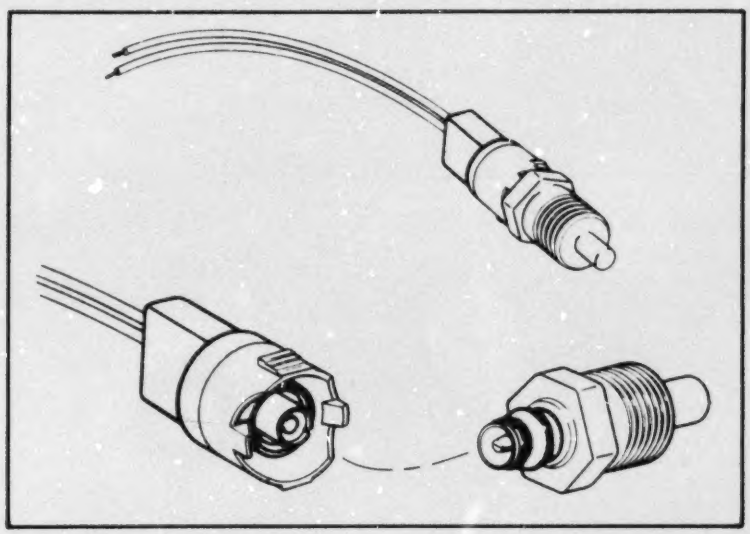
1. Sends computer the temperature of engine coolant

2. Allows computer to regulate exhaust gas recirculation, air management, and early fuel evaporation

(NOTE: When the coolant temperature is below a certain level, i.e., 150°F [66°C], the computer ignores input from the oxygen sensor and operates in what is termed an *open loop* condition. After the engine has warmed up, the computer considers oxygen sensor input in air-fuel regulation and operates in a condition known as *closed loop*.)

EXAMPLE:

FIGURE 3



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C. Pressure sensors (Figure 4)

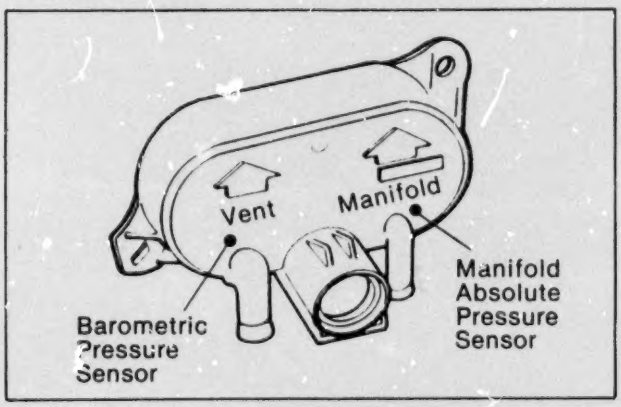
1. Send computer changes in manifold pressure and barometric pressure

2. Allow computer to adjust air-fuel mixture for changes in weather, altitude, and engine load

(NOTE: The two sensors are usually combined in one unit.)

EXAMPLE:

FIGURE 4



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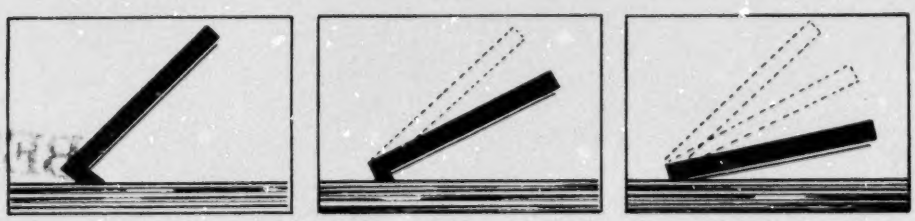
D. Throttle position sensor (See Figure 6)

1. Sends computer the position of accelerator pedal (Figure 5) and throttle blades

EXAMPLE:

FIGURE 5



- Closed Throttle (Idle or Deceleration)
- Part Throttle (Normal Operation)
- Wide-Open Throttle (Maximum Acceleration)

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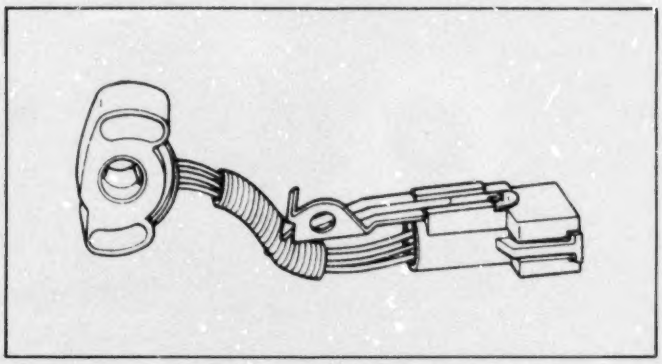
2. Allows computer to adjust air-fuel mixture, spark timing, air diversion, and exhaust gas recirculation

EXAMPLE:

FIGURE 6



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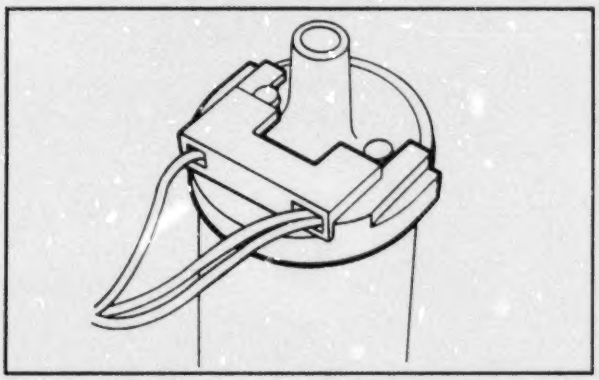
E. Engine rpm sensor (Figure 7)

1. Sends computer the crankshaft position and engine rpm by monitoring crankshaft or electronic ignition unit

2. Allows computer to regulate spark timing

EXAMPLE:

FIGURE 7



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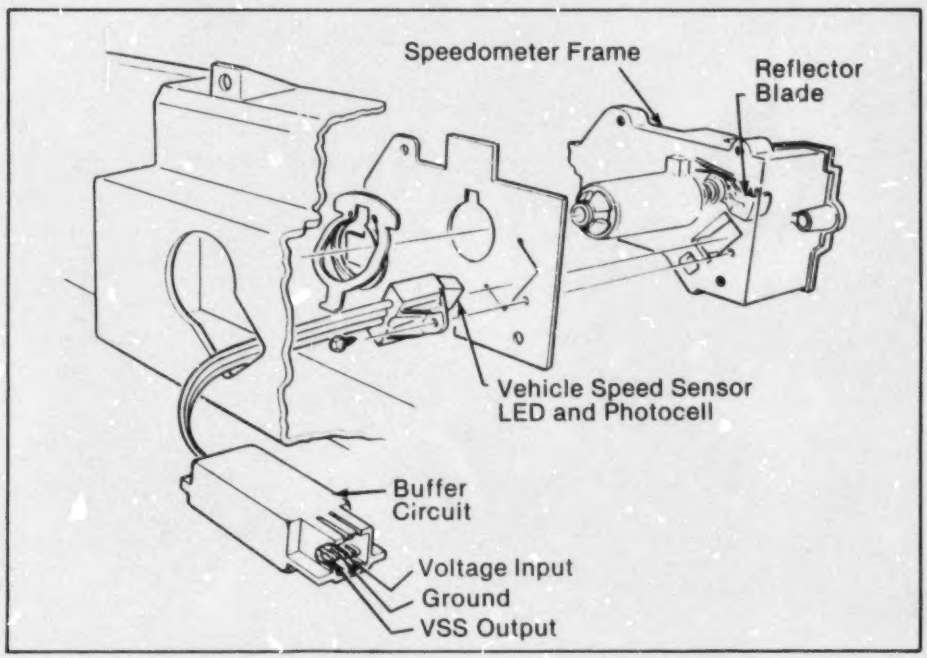
F. Vehicle speed sensor (Figure 8)

1. Sends vehicle speed to computer via light-emitting diode

2. Provides information which, when coordinated with engine rpm and throttle position, allows computer to regulate air-fuel mixture, spark timing, computerized automatic transmission control, shift indicator actuation, and cruise control

EXAMPLE:

FIGURE 8



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G. Knock sensor (Figure 9)

1. Sends computer frequency of detonation sounds

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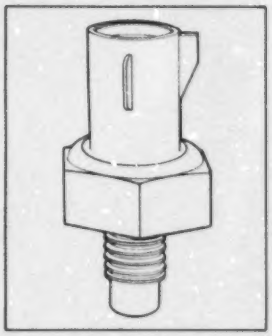
2. Allows computer to regulate spark timing

(NOTE: The knock sensor is sensitive to other noises and vibrations, and it is possible for the computer to regulate spark timing erroneously in response to rattles caused by loose parts.)

EXAMPLE:

FIGURE 9



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V. Locations of automotive computer system sensor components (Figure 10)

(NOTE: Check manufacturers' manuals for specific locations of all computer system components.)

A. Oxygen sensor — Exhaust manifold

B. Engine coolant temperature sensor — Engine water jacket, usually near thermostat housing

C. Pressure sensors — Various locations; usually on rear or side walls of engine compartment

D. Throttle position sensor — Side of throttle body or inside carburetor

E. Engine rpm sensor

1. Crankshaft position sensor — Front of timing gear cover

2. Electronic ignition rpm sensor — Ignition coil or distributor output signal wire

F. Vehicle speed sensor — Rear of speedometer housing or in transmission housing

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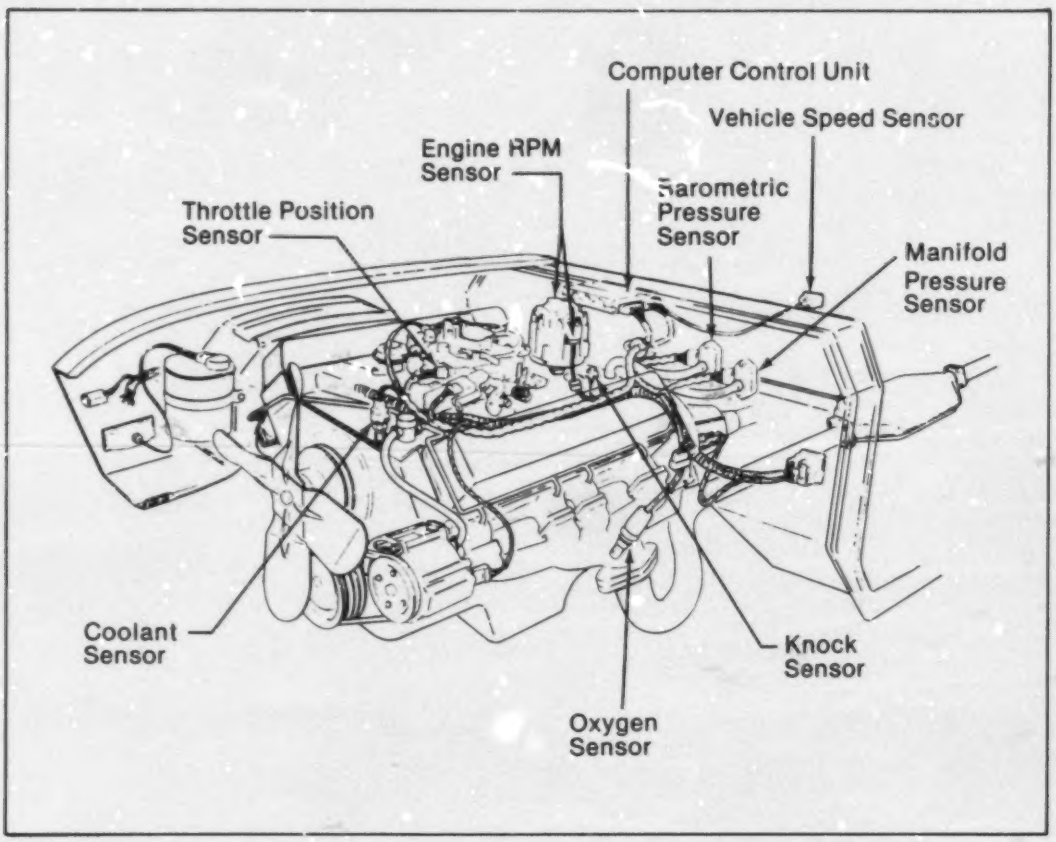
G. Knock sensor — Intake manifold or engine block

EXAMPLE:

FIGURE 10



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VI. Functions of automotive computer system actuators

(NOTE: Other computer-controlled actuators may be used, but the following are the most common.)

A. Air-fuel mixture control

1. Carburetor system (Figures 11 and 12)

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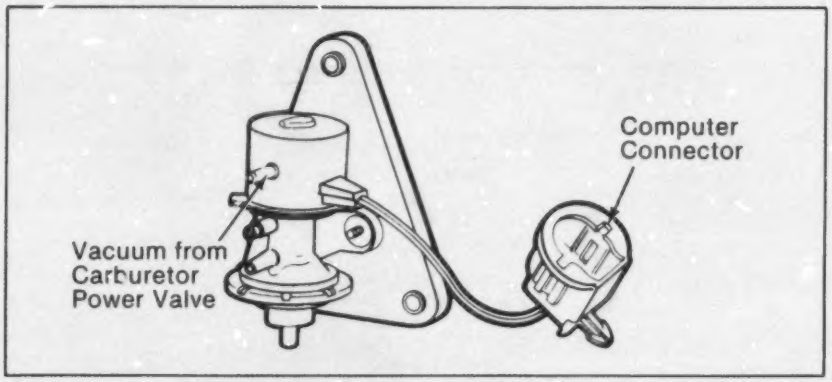
a. Computer sends electrical impulses to solenoids to adjust the metering orifices for proper air-fuel mixture

EXAMPLE:

FIGURE 11



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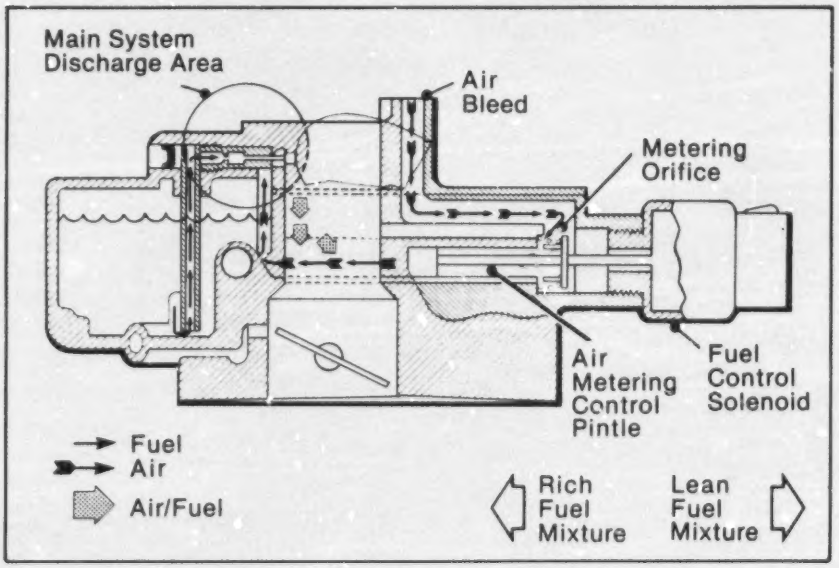
b. Width of orifice opening or the length of time it is open regulates amount of air fed into carburetor

EXAMPLE:

FIGURE 12



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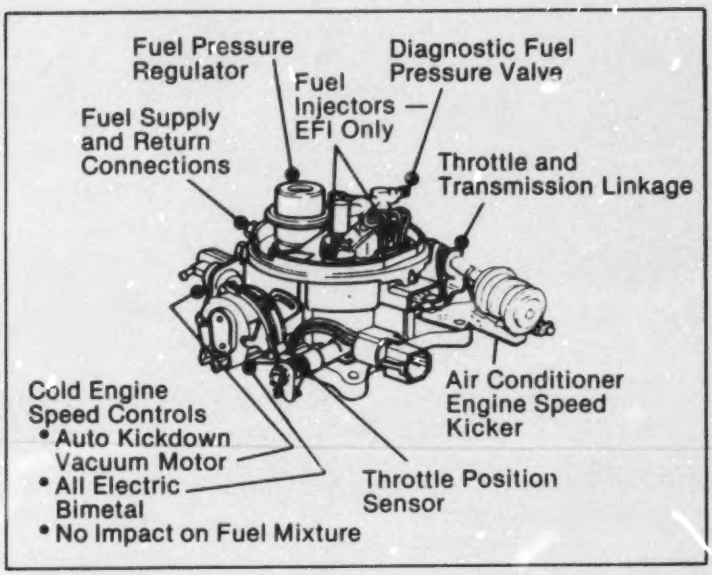
2. Fuel-injection system — injectors open and close on computer command; amount and frequency of opening control fuel for combustion mixture (Figures 13 and 14)

EXAMPLES:

FIGURE 13


Fuel Pressure Regulator
Diagnostic Fuel Pressure Valve
Fuel Injectors — EFI Only
Fuel Supply and Return Connections
Throttle and Transmission Linkage
Air Conditioner Engine Speed Kicker
Cold Engine Speed Controls
• Auto Kickdown Vacuum Motor
• All Electric Bimetal
• No Impact on Fuel Mixture
Throttle Position Sensor

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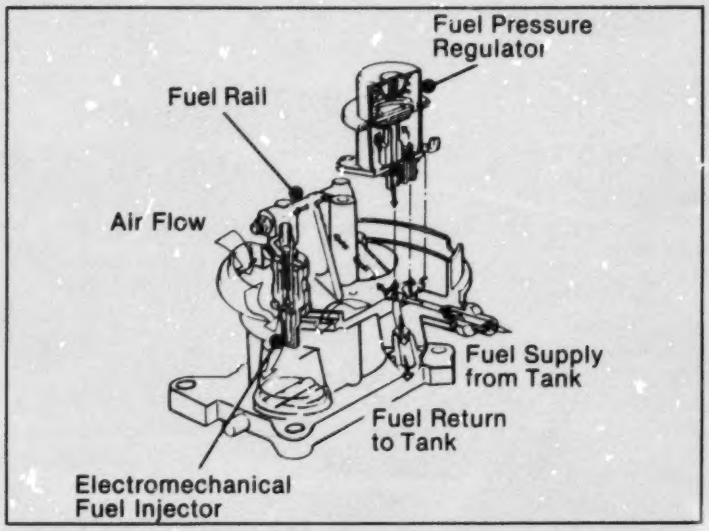
FIGUPE 14



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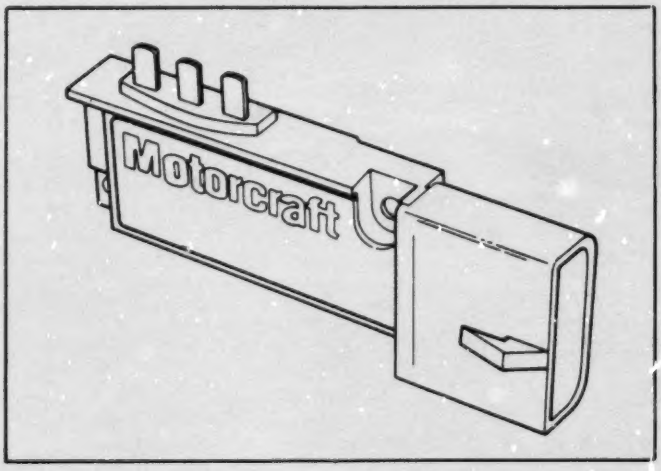
B. Ignition timing control — Firing time of spark plug is regulated by computer in response to input signals such as those of knock sensor (Figure 15)

(NOTE: Engine knock not only decreases fuel economy and engine performance but can lead to internal engine damage if left unchecked.)

EXAMPLE:

FIGURE 15



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C. Engine idle speed — Throttle position is adjusted to maintain engine speed at constant rate despite additional loads placed on engine, such as placing automatic transmission in gear or turning on air conditioner (Figures 16 and 17)

(NOTE: The systems for maintaining engine idle speed vary a great deal mechanically but generally involve the use of a stepper motor and solenoids. Some industry terms for these actuators include *vacuum operated throttle modulator* [*VOTM*], *throttle kicker solenoid* [*TKS*], and *idle speed control* [*ISC*].)

EXAMPLES:

FIGURE 16

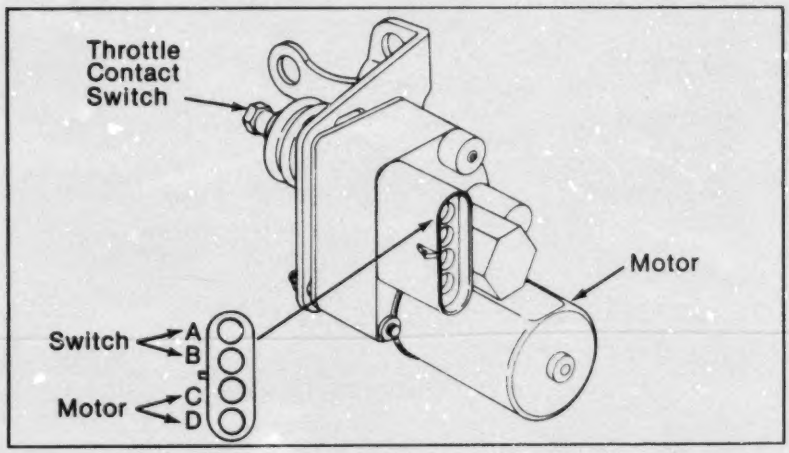

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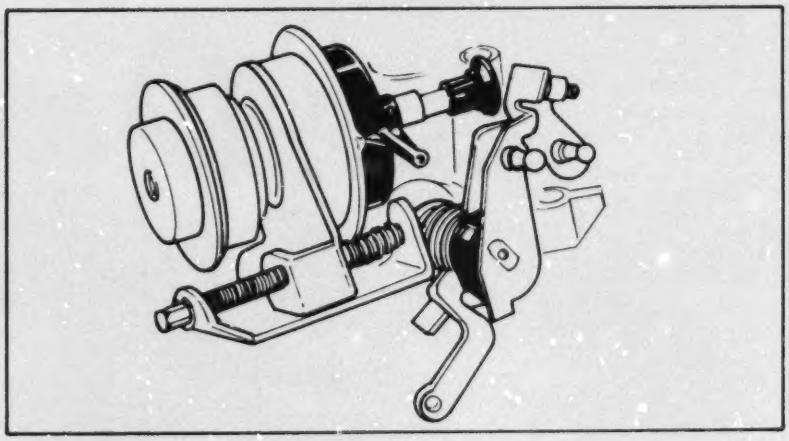
FIGURE 17



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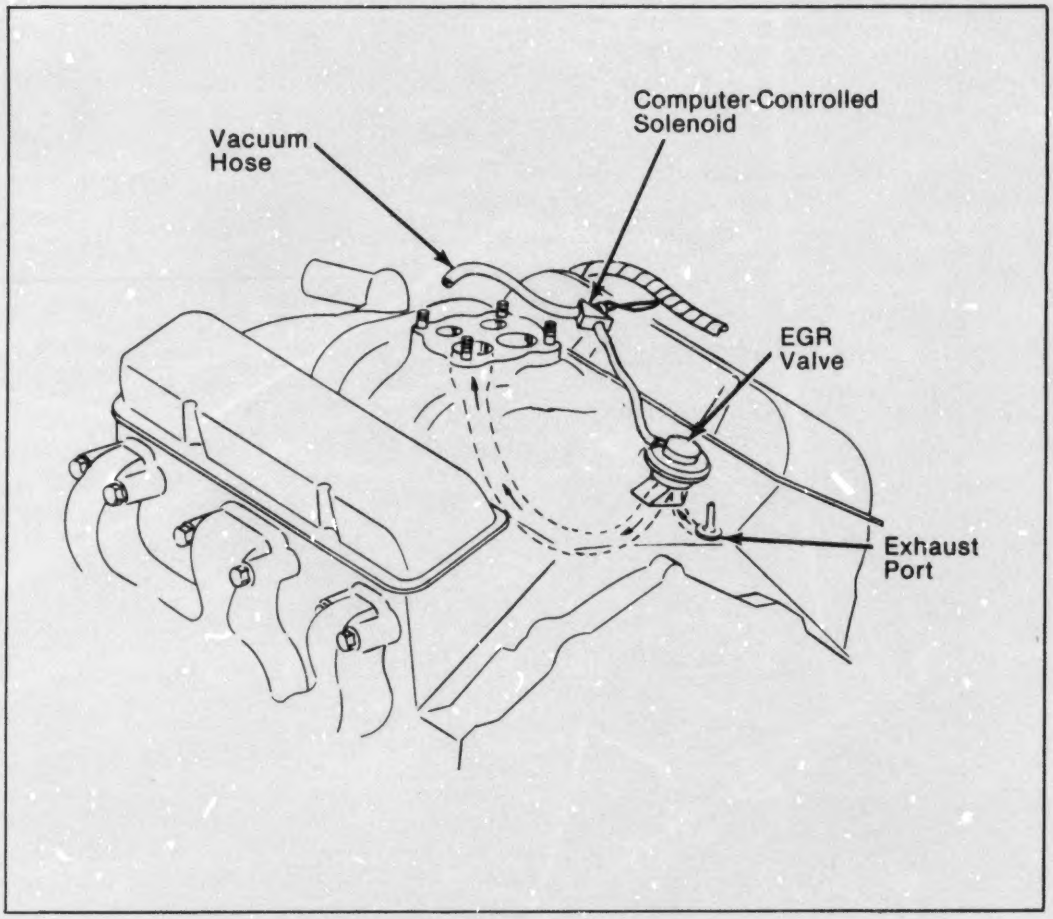
D. Exhaust gas recirculation — On computer command, solenoid valve in vacuum line opens and closes exhaust gas recirculation valve to allow exhaust gases into the intake manifold to aid in emission control and to reduce combustion temperatures (Figure 18)

(NOTE: This system is basically the same as the EGR system that has been in use for several years; however, computer control allows more precise operation.)

EXAMPLE:

FIGURE 18



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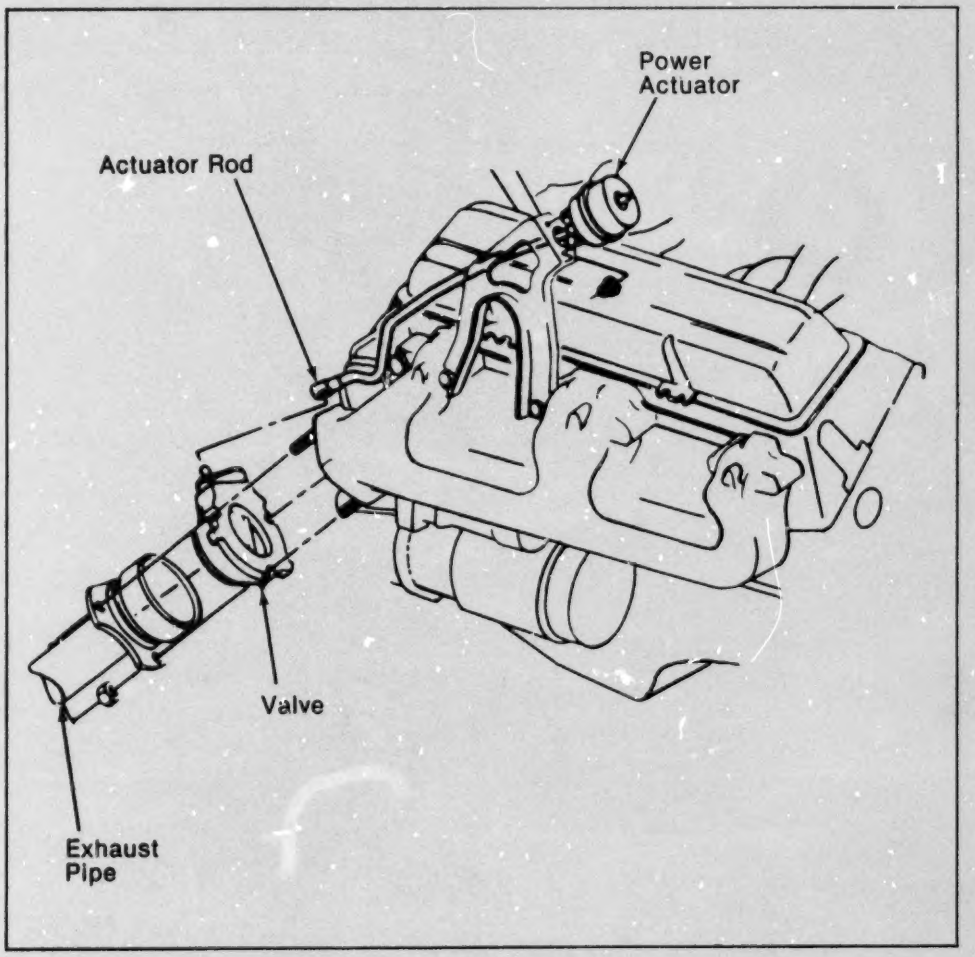
E. Exhaust manifold heat control — On computer command, vacuum-controlled solenoids operate to circulate exhaust gases around carburetor base during cold engine operation to improve atomization and to assist with choke warm-up (Figure 19)

(NOTE: This system is similar to that of the earlier model heat riser valves that employed the use of a bimetal spring for thermostatic control.)

EXAMPLE:

FIGURE 19



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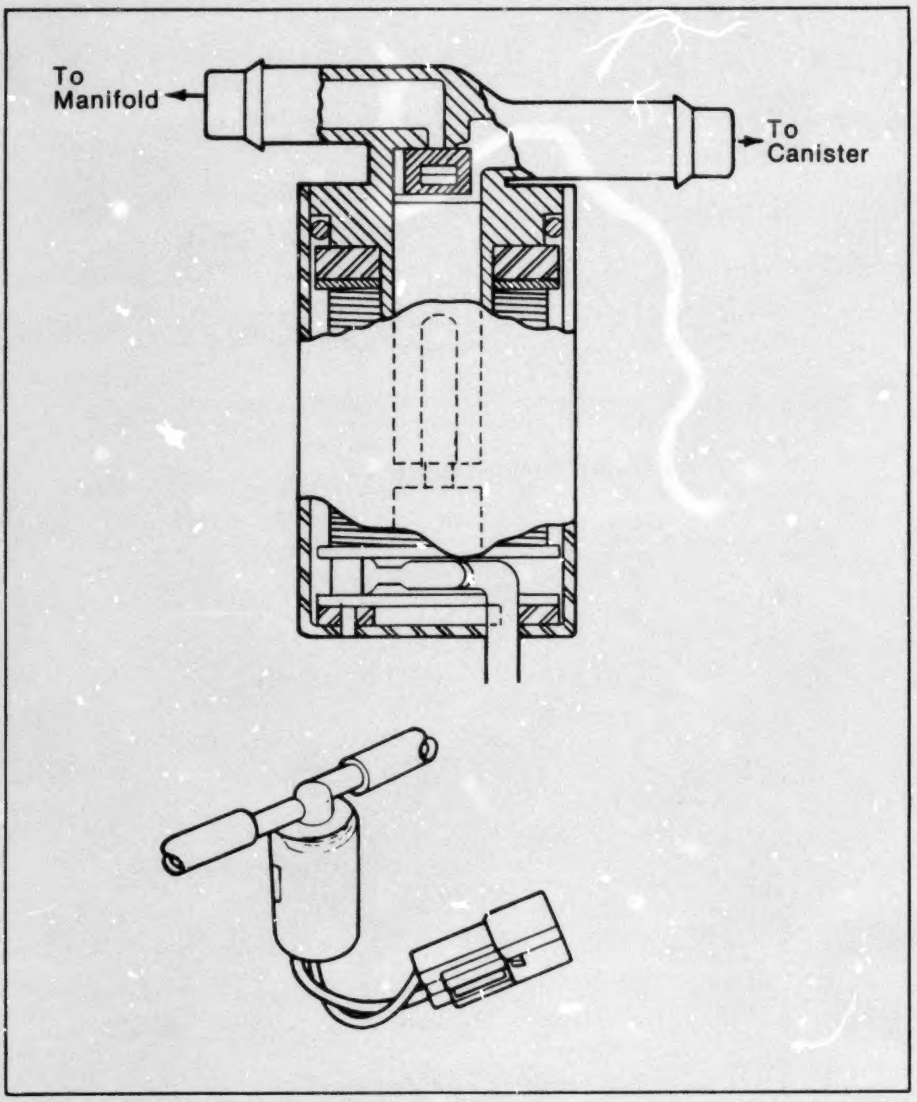
F. Evaporative gas canister purge — On computer command through use of a solenoid, gas vapors from fuel tank are stored in a charcoal canister and combined with air-fuel mixture in intake manifold (Figure 20)

EXAMPLE:

FIGURE 20



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G. Air supply management — Diverter valves, controlled by electronic solenoids, direct pumped air to various components to improve combustion efficiency in the engine (Figure 21)

1. Air is directed to exhaust manifold to provide more complete combustion of fuel escaping the combustion chamber

2. Air is directed to air cleaner to prevent backfire on deceleration and to aid fuel economy

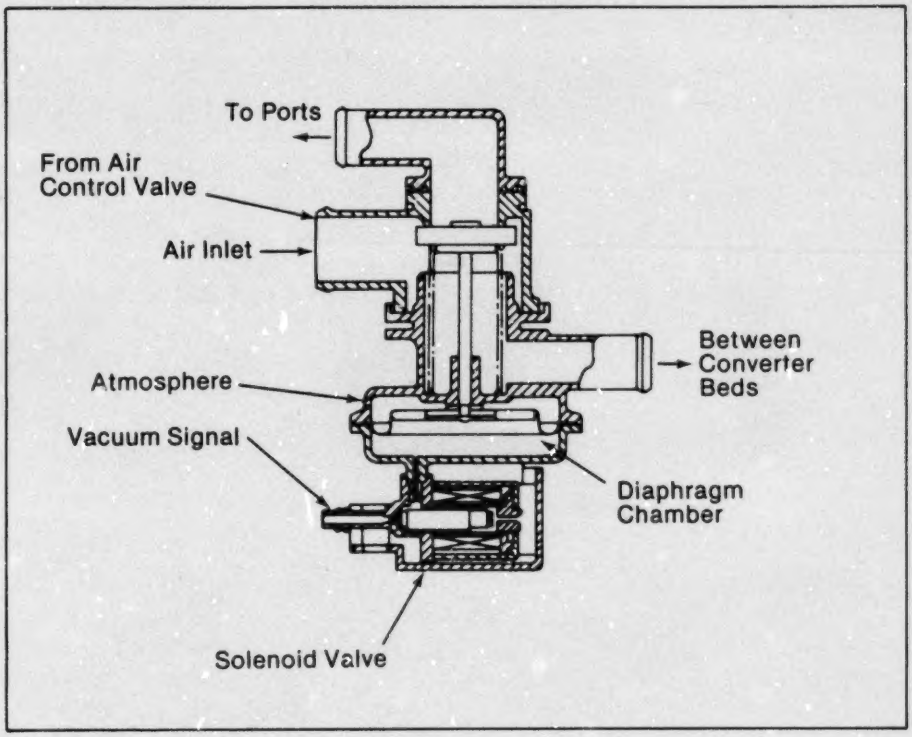
3. Air is directed into catalytic converter to improve combustion and to help converter reach operating temperature quickly

(NOTE: The air increases the oxygen in the catalytic converter to speed up the chemical reaction, just as a bellows can be used to increase a flame.)

EXAMPLE:

FIGURE 21

Electric Air Switching Valve



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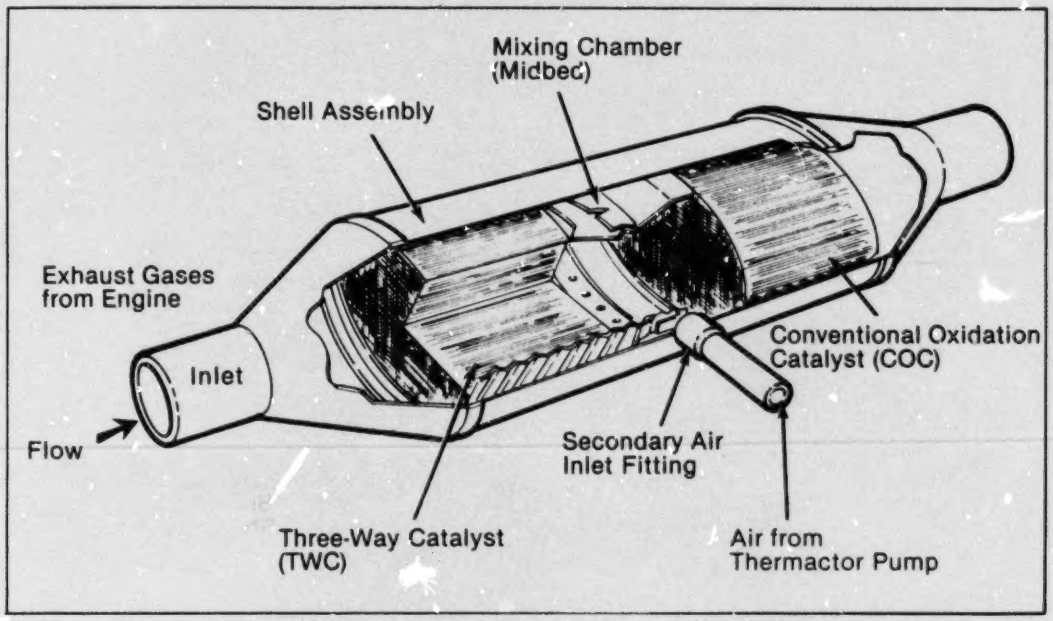
VII. Characteristics of a three-stage catalytic converter (Figure 22)

A. Contains platinum and paladium to neutralize hydrocarbons and carbon monoxide as with earlier-model converters

B. Contains rhodium to control oxides of nitrogen (NOx)

EXAMPLE:

FIGURE 22



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VIII. Preliminary steps in servicing a vehicle with an automotive computer system

A. Carefully note driver's complaints and comments

(NOTE: It is especially important that the service technician listen courteously to customer complaints regarding vehicles equipped with computer controls. A large segment of the public is suspicious of technological advances, often suspecting manufacturers of deliberately making vehicles expensive and difficult to service. Many people tend to blame the computer for completely unrelated problems, such as faulty dome lights, inoperative radios, and squeaky doors.)

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B. Perform visual inspection and routine checks (Figure 23)

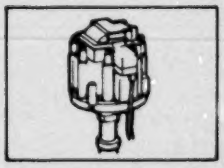
(NOTE: Be sure to inspect all electrical connections and to check for proper grounding. Remember that the majority of the components on a vehicle with an automotive computer system are identical to those on other modern vehicles. Even the fuel and air management systems are essentially the same, except that a computer operates electronic devices that previously may have been vacuum controlled or mechanically controlled. The majority of vehicle service requirements will continue to involve components that you already know how to service.)

EXAMPLES:

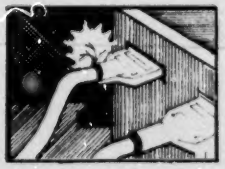
FIGURE 23

Spark Plugs
- Fouled Plugs
- Burned Plugs
- Wrong Plugs

Carburetor
- Incorrect Fuel Level
- Improper Settings or Internal Failure (Metering, Idle, Choke)
- Mechanical Failure (Linkage, Leaky Float)

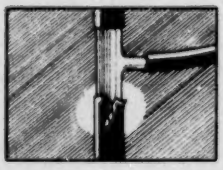


Distributor
- Open or Shorted Circuits
- Wear or Damage (Cracks, Water Damage)



Electrical System
- Loose or Disconnected Wires
- Crimped, Frayed, or Broken Wires
- Shorts Between Wires

Cooling System
- Damage
- Improper Coolant or Level
- Improper or Malfunctioning Thermostat



Vacuum System
- Leaky Connections
- Leaks in Lines
- Improperly Routed Lines

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C. Perform quick test if computer-related problem is indicated

(NOTE: Be sure that the quick test is the correct procedure for the make and model of vehicle as equipped. Do not deviate from the test procedure.)

IX. Methods of performing a quick test of the automotive computer system

A. Reading "check engine" light (Figure 24)

1. "Check engine" light on instrument panel flashes to identify a trouble code number when a specified computer terminal is grounded

a. One flash followed by a pause represents the number 1, two flashes followed by a pause represents the number 2, and so on

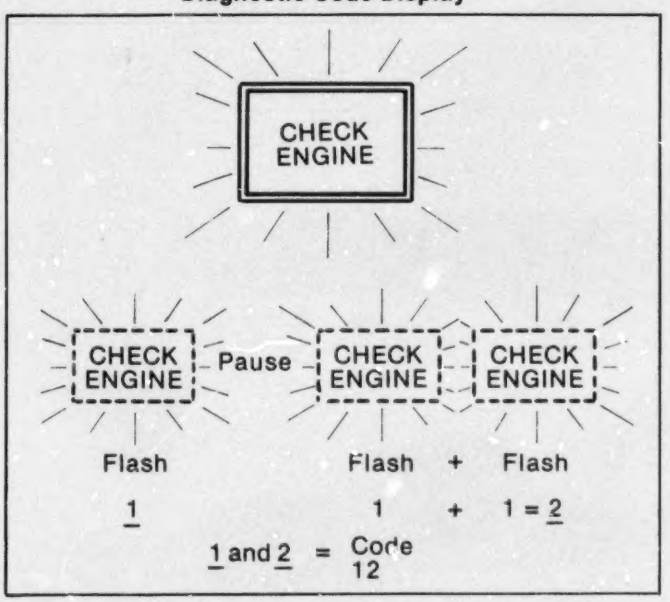
b. The two-digit trouble code will be repeated

2. If more than one trouble code is present, each trouble code will be flashed three times, beginning with the lowest number; when all codes have been displayed, the sequence will be repeated

EXAMPLE:

FIGURE 24

Diagnostic Code Display



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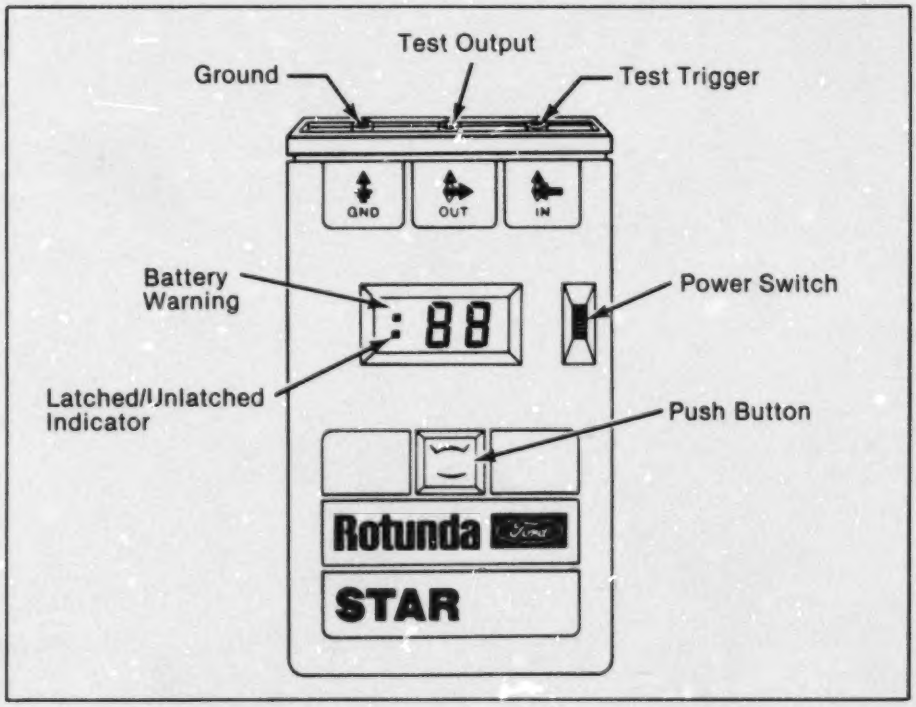
B. Using special test equipment (Figure 25)

1. Technician follows manufacturer's instructions to ground computer or connect jumper to create a test circuit
2. Special equipment is then hooked into the test circuit
3. Test equipment displays a trouble code number on its screen

EXAMPLE:

FIGURE 25



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C. Using analog voltmeter

1. Some systems designed to be quick tested with special test equipment may be checked with an analog voltmeter, following manufacturer's instructions

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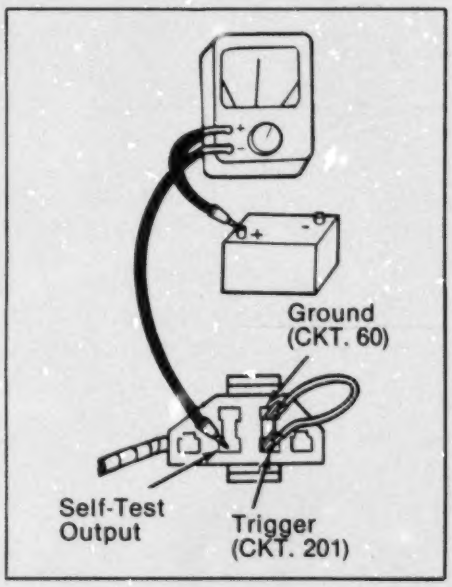
2. Voltmeter is connected to the proper terminals (Figure 26)

EXAMPLE:

FIGURE 26



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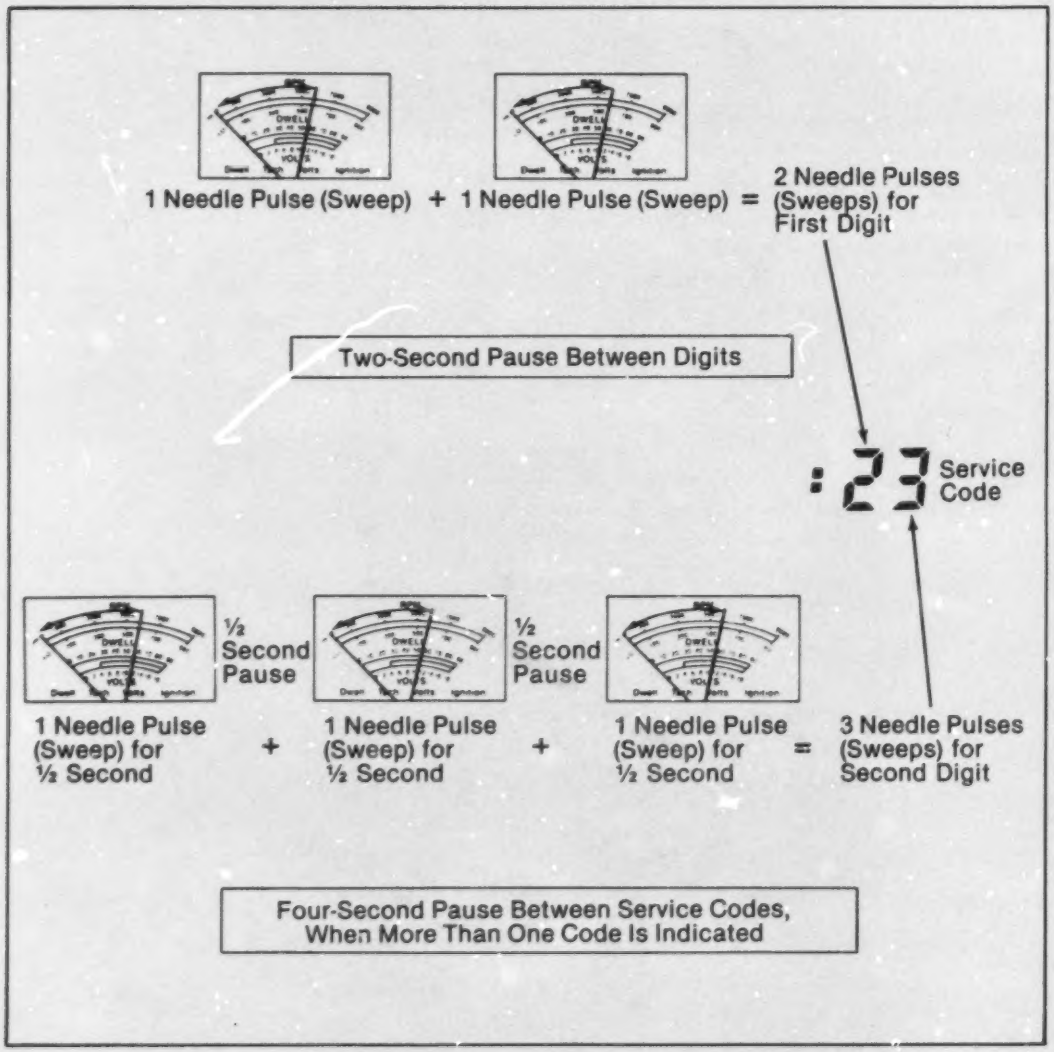
3. Sweeps of voltmeter needle indicate code number (Figure 27)

EXAMPLE:

FIGURE 27


1 Needle Pulse (Sweep) + 1 Needle Pulse (Sweep) = 2 Needle Pulses (Sweeps) for First Digit
Two-Second Pause Between Digits
: 23 Service Code
½ Second Pause
½ Second Pause
1 Needle Pulse (Sweep) for ½ Second + 1 Needle Pulse (Sweep) for ½ Second + 1 Needle Pulse (Sweep) for ½ Second = 3 Needle Pulses (Sweeps) for Second Digit
Four-Second Pause Between Service Codes, When More Than One Code Is Indicated

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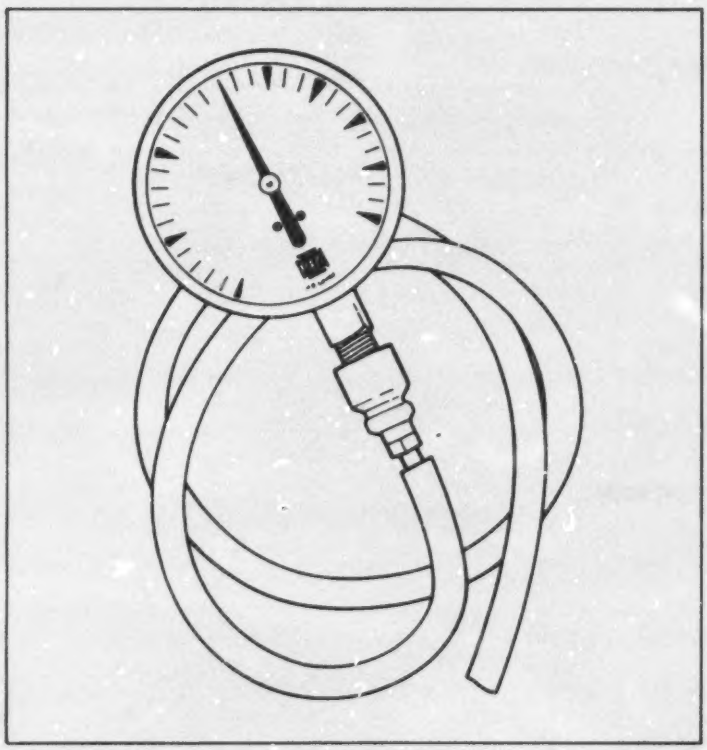
D. Using vacuum gauges (Figure 28)

1. Some codes on some models may be read using vacuum gauges
2. Vacuum gauges are connected to vacuum lines of thermactor air-control solenoids
3. Sweeps of gauge needles indicate trouble-code numbers

EXAMPLE:

FIGURE 28



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X. Guidelines for performing a pinpoint test of the automotive computer system

A. Follow all test procedures exactly

B. Do not replace any component unless test results indicate that it should be replaced

C. If more than one code is displayed during the quick test, begin the pinpoint test procedure with the first code number given

D. Do not measure voltage or resistance at any component or connect a test light unless the procedure calls for it

E. Make sure that the electrical values of equipment used are within the ranges specified

(NOTE: Be especially careful with older equipment that may not be sensitive enough or have the proper ranges required for the tests.)

F. Be sure to make proper contact with test probes

G. Do not measure resistance, check continuity, or attempt to energize solenoids or switches without first isolating the component from other components

H. Compare electrical values to those specified by the manufacturer for the exact test conditions being used

I. Use only procedure specified for the particular make and model of vehicle as equipped

J. Erase codes in memory if so directed by procedure

(NOTE: Codes are normally erased by disconnecting the computer from its power source for at least ten seconds.)

K. Repeat quick test to verify that problem has been corrected

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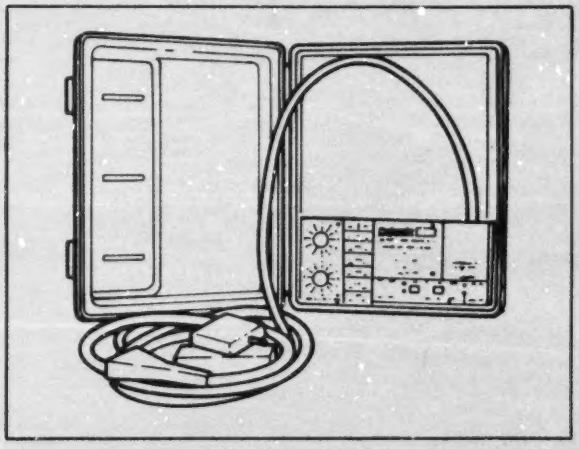
XI. Uses of automotive computer system test equipment

(NOTE: Test equipment used must be that authorized by the vehicle manufacturer, or must be an equivalent, authorized substitute.)

A. Special test equipment — Used to test specific system characteristics and functions, often for the equipment of a given manufacturer (Figure 29)

EXAMPLE:

FIGURE 29



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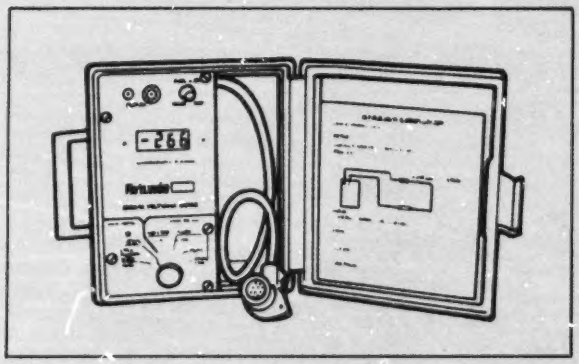
B. Digital voltohmmeter (DVOM) — Used to check electrical currents and circuit characteristics; specially designed to give precise readouts for low-voltage circuits (Figure 30)

EXAMPLE:

FIGURE 30



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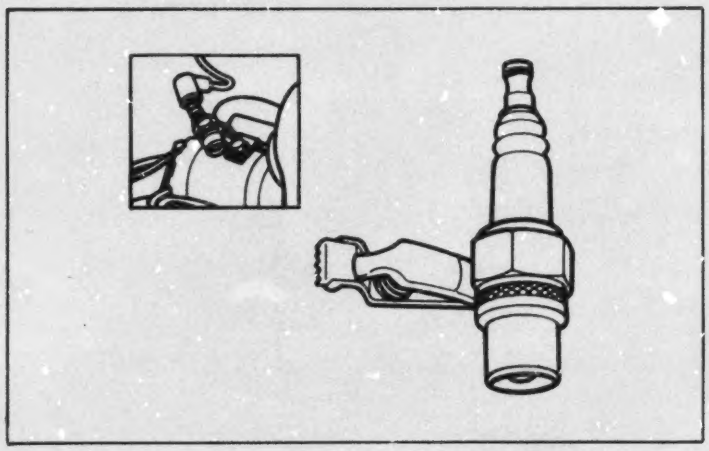
C. Spark tester adapter — Used to check for proper ignition spark (Figure 31)

(CAUTION: Any open circuit created in the electronic ignition system could result in serious damage to electronic components.)

EXAMPLE:

FIGURE 31



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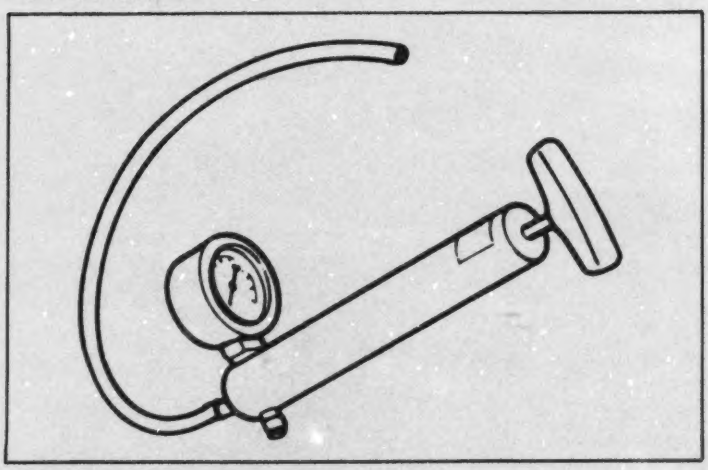
D. Hand-operated vacuum pump — Used to apply specific vacuums to pressure-sensitive sensors and actuators (Figure 32)

EXAMPLE:

FIGURE 32



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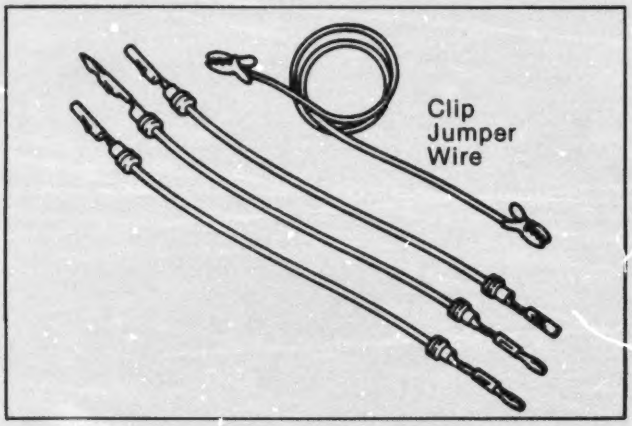
E. Jumper leads — Used to bypass circuits (Figure 33)

(NOTE: Jumper lead connectors must be compatible with the system terminals, and must be properly attached to give accurate indications.)

EXAMPLE:

FIGURE 33



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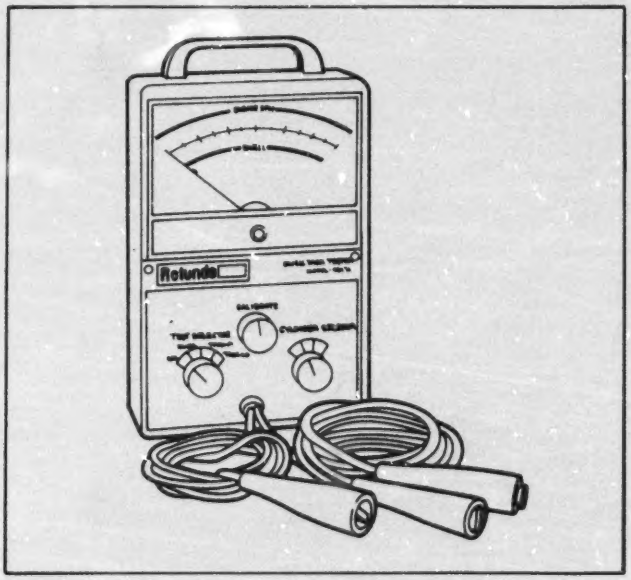
F. Tachometer — Used to indicate engine revolutions per minute (Figure 34)

EXAMPLE:

FIGURE 34



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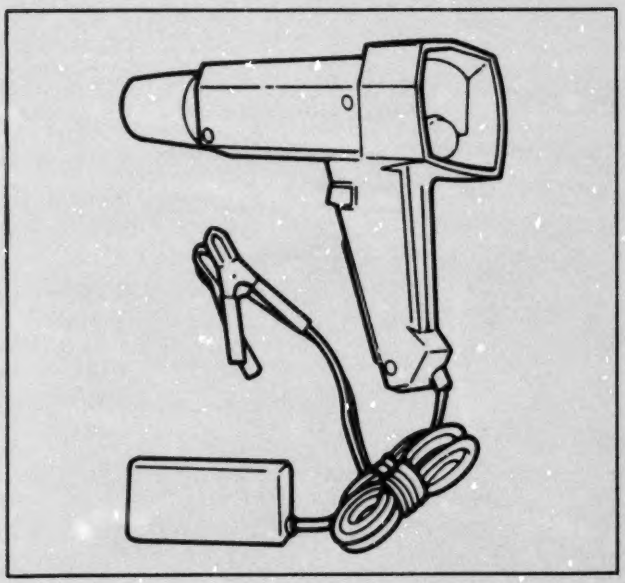
G. Timing light — Used to indicate ignition timing (Figure 35)

(NOTE: For electronic component systems, the timing light must be equipped with a timing advance meter.)

EXAMPLE:

FIGURE 35



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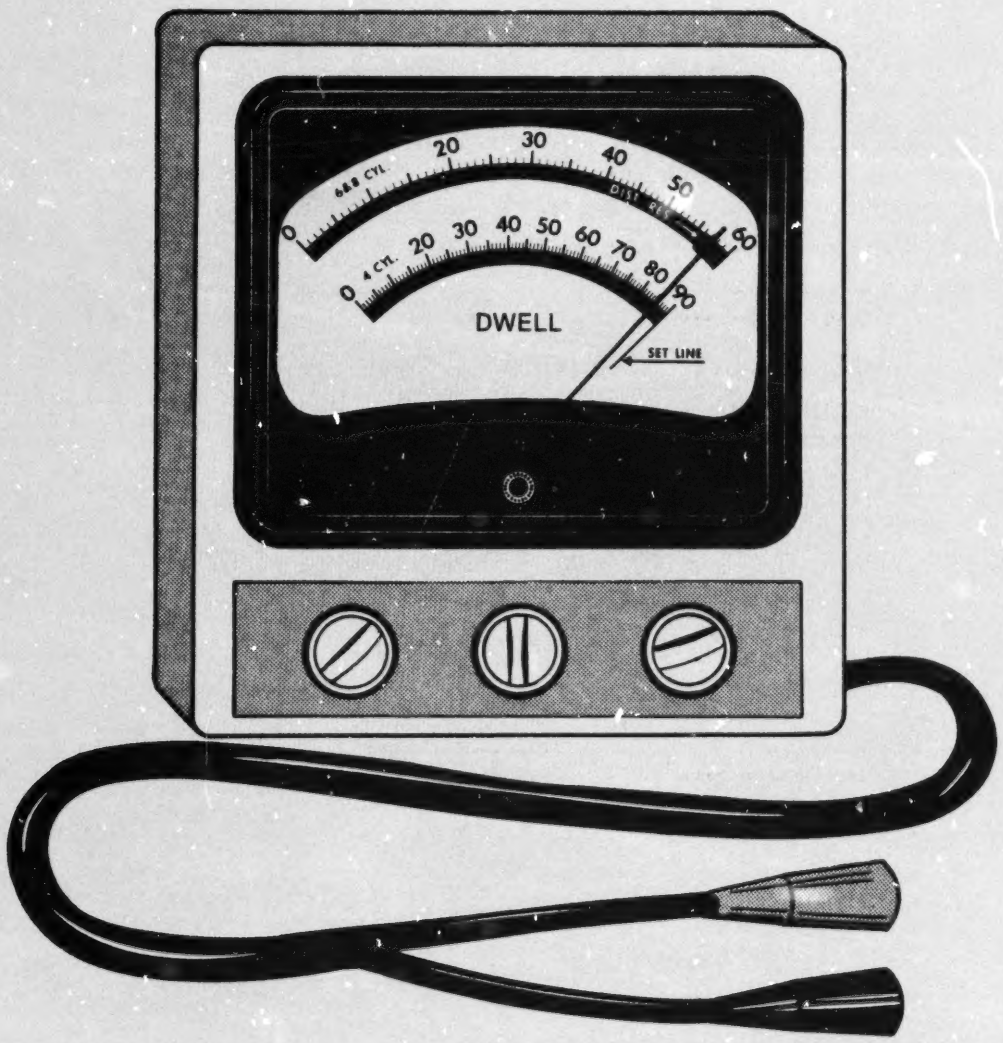
H. Dwell meter — Used to measure pulse patterns to electrically controlled solenoids (Figure 36)

(NOTE: Whereas the timing light and tachometer perform pretty much the same function on computer-controlled and non-computer-controlled vehicles, dwell meters used for computer systems must be low-resistance types with readings taken on a properly calibrated six-cylinder scale.)

EXAMPLE:

FIGURE 36



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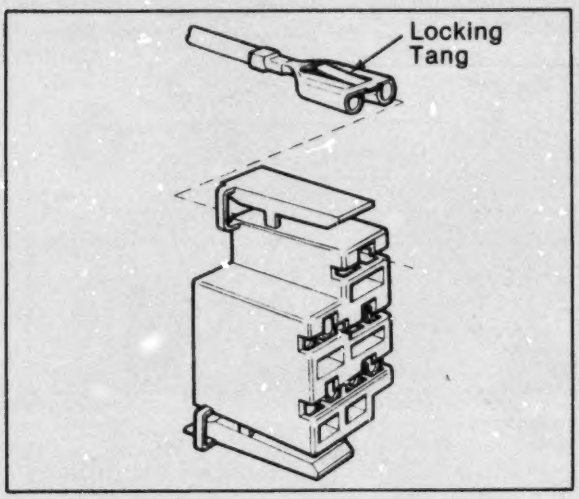
XII. Types of automotive computer system electrical connectors

A. Blade-type (Figure 37)

FIGURE 37



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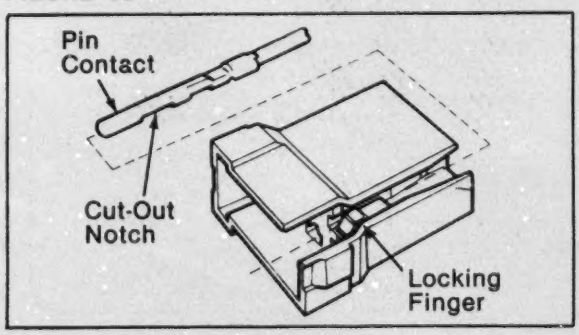
B. Pin-type (Figure 38)

FIGURE 38



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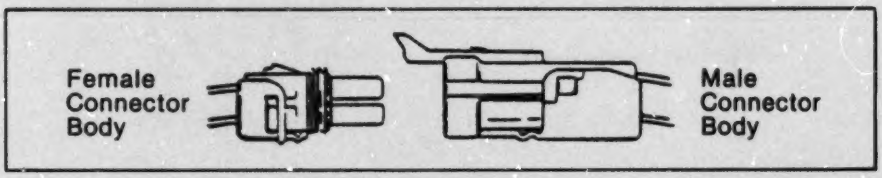
C. Weather-pack terminal (Figure 39)

FIGURE 39



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XIII. Guidelines for splicing conductors in automotive computer systems

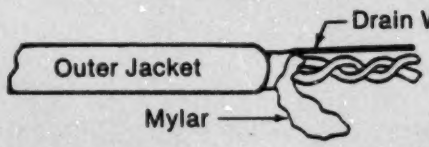
A. Follow manufacturer's recommendations as to the kind of splice to make (Figures 40 and 41)

EXAMPLES:

FIGURE 40

Twisted/Shielded Cable

1. Remove outer jacket.
2. Unwrap aluminum/mylar tape. Do not remove mylar.



3. Untwist conductors. Strip insulation as necessary.

4. Splice wires using splice clips and rosin core solder. Wrap each splice to insulate.

5. Wrap with mylar and drain (uninsulated) wire.
6. Tape over whole bundle to secure as before.

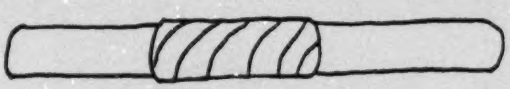


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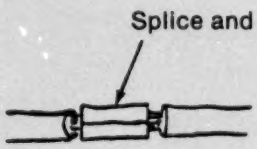
FIGURE 41

Twisted Leads

1. Locate damaged wire.
2. Remove insulation as required.

3. Splice two wires together using splice clips and rosin core solder.



4. Cover splice with tape to insulate from other wires.
5. Retwist as before and tape with electrical tape to hold in place.

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B. Solder all splices

C. Use only conductors with high-temperature insulation

D. Use only the same gauge of wire used by the manufacturer

E. Cut replacement conductors to the same length as the portion of wire replaced

(NOTE: Changes in the length or gauge of the wire will change the resistance of the system. Because of the low voltages and amperages used in automotive computer systems, any increase in resistance will affect the operation of the system.)

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AUTOMOTIVE COMPUTER UNITS
AUTO MECHANICS SUPPLEMENT

ASSIGNMENT SHEET #1 — USE SERVICE MANUAL EXCERPTS TO DETERMINE PROCEDURES IN RESPONSE TO AUTOMOTIVE COMPUTER TROUBLE CODES

NAME _____ SCORE _____

This assignment sheet, which includes charts taken from automotive service manuals, allows the technician to practice diagnosing computer-monitored problems by interpreting service manual test charts. It also provides practice in determining the required procedures in response to test indications.

Procedures for determining the technician's actions in servicing computer-controlled engines must be followed exactly. Deviation from test procedures can result in equipment damage, and will almost certainly produce incorrect readings in the test equipment. The ability to interpret manufacturers' flow diagrams and charts is essential in correcting problems.

Analyze the following problems, referring to Information Sheet, Section VIII and the appropriate service manual charts on the following pages. Complete each statement by filling in the blanks with the proper terms. Answer questions in the spaces provided.

A. A customer enters the service department with a 1983 Chevrolet Impala four-door V-8 and states that the "check engine" light is on, that she has noticed a foul odor like rotten eggs, and that the car's fuel economy has become very poor.

1. In your analysis you should conduct a _____ inspection of the engine compartment and related components.

2. You would then check engine components that may lead to problems not monitored by the computer. List four such components.

   a. _____

   b. _____

   c. _____

   d. _____

3. In diagnosing the problem, be sure to follow through on all of the customer's

   _____.

4. Outline the steps required to call up the trouble codes on this vehicle, using the "check engine" light.

   _____

   _____

ASSIGNMENT SHEET #1

5. The "check engine" light indicates a code 45. After connecting the dwell meter to the M/C solenoid, what would you do if

   a. Dwell meter reads under 50°?

   _____

   _____

   _____

   b. Dwell meter reads over 50°?

   _____

   _____

   _____

6. What would you do if, after you remove a PVC vacuum hose,

   a. Dwell drops?

   _____

   _____

   _____

   _____

   b. Dwell does not drop?

   _____

   _____

7. After taking the actions you listed in step 6b, what would you do if

   a. Dwell drops below 10°?

   _____

   _____

   b. Dwell does not change?

   _____

   _____

ASSIGNMENT SHEET #1

8. If the dwell had dropped below 10° and you performed the actions that you listed in step 7a, what part is faulty if

   a. Voltage from oxygen sensor to ground is under 0.55 volts?

   _____

   b. Voltage from oxygen sensor to ground is over 0.55 volts?

   _____

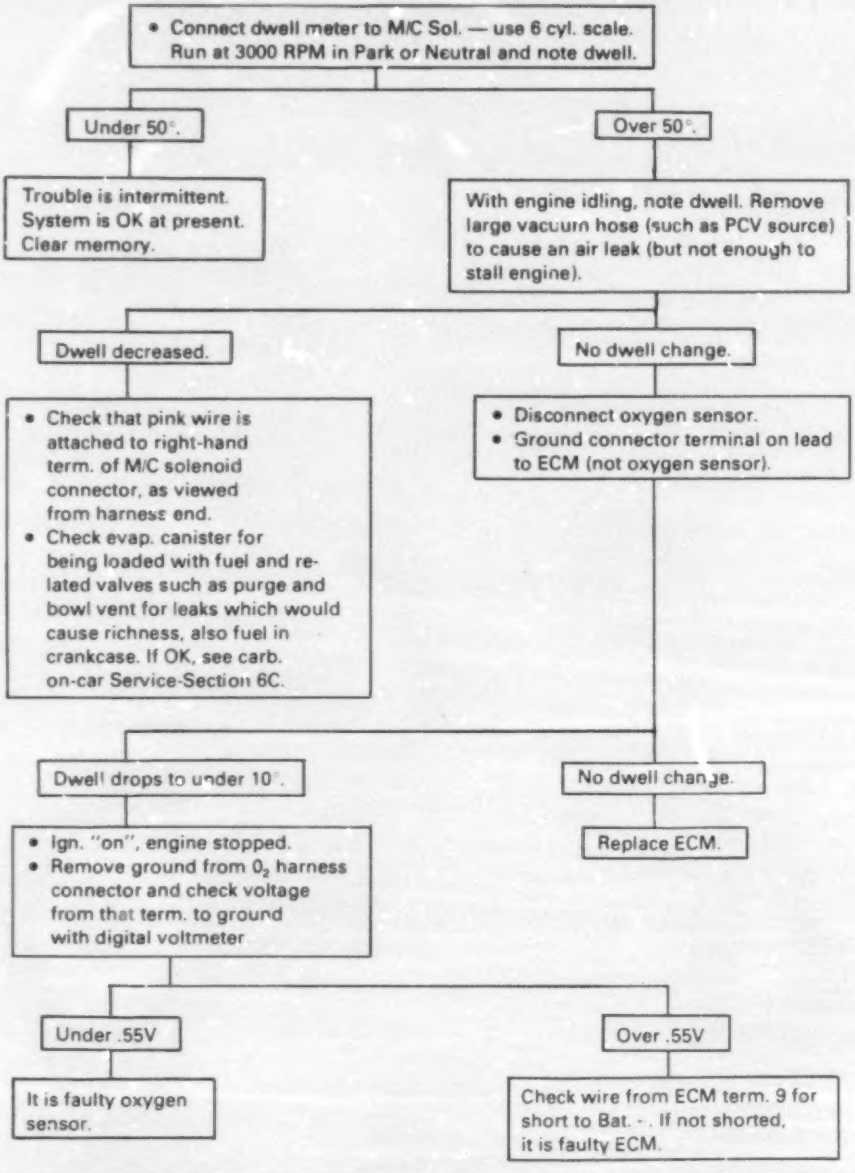
   _____

ASSIGNMENT SHEET #1

1983 General Motors V-8 (Except CKG Truck)

TROUBLE CODE 45: Rich Exhaust Indication

If M/C solenoid does not click with ign. "on" and "Test" term. grounded and there is no Code 23 or 54, check for sticking solenoid. If code 54 is present, go to Chart 54 first.


• Connect dwell meter to M/C Sol. — use 6 cyl. scale. Run at 3000 RPM in Park or Neutral and note dwell.
Under 50°.
Over 50°.
Trouble is intermittent. System is OK at present. Clear memory.
With engine idling, note dwell. Remove large vacuum hose (such as PCV source) to cause an air leak (but not enough to stall engine).
Dwell decreased.
No dwell change.
• Check that pink wire is attached to right-hand term. of M/C solenoid connector, as viewed from harness end.
• Check evap. canister for being loaded with fuel and related valves such as purge and bowl vent for leaks which would cause richness, also fuel in crankcase. If OK, see carb. on-car Service-Section 6C.
• Disconnect oxygen sensor.
• Ground connector terminal on lead to ECM (not oxygen sensor).
Dwell drops to under 10°.
No dwell change.
• Ign. "on", engine stopped.
• Remove ground from 0_2 harness connector and check voltage from that term. to ground with digital voltmeter
Replace ECM.
Under .55V
Over .55V
It is faulty oxygen sensor.
Check wire from ECM term. 9 for short to Bat. +. If not shorted, it is faulty ECM.

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ASSIGNMENT SHEET #1

B. A customer enters the service department with a 1981 Ford Mustang equipped with a 2.3L, four-cylinder engine, and complains of poor performance and a foul odor when the car is running.

1. Your preliminary checks indicate that the problem may involve the automotive computer system. Describe the procedure you would use to call up the trouble codes on this vehicle using an analog voltmeter.

_____

_____

_____

2. The swing of the voltmeter needle indicates a trouble code 42. What would you do to prepare for the service procedure operations?

_____

_____

_____

_____

3. When you check circuits 687 and 95, what would you do if

   a. Resistance is less than 5 ohms?

   _____

   _____

   b. Resistance is more than 5 ohms?

   _____

4. If circuits 687 and 95 read less than 5 ohms and the vacuum lines are clear and intact, what would you do if

   a. The vacuum gauge reads less than 2.5" Hg?

   _____

   _____

   _____

   _____

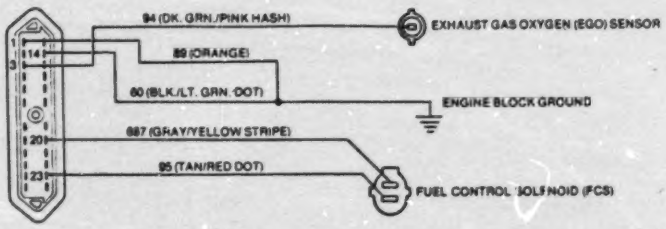
ASSIGNMENT SHEET #1

b. The vacuum gauge reads more than 2.5" Hg?

5. Assume that the vacuum gauge reading in step 4 was more than 2.5" Hg and that you performed the procedure you described in step 4b. What would you do next if the voltmeter reading was 0.5 volt?

6. If the voltmeter continues to read 0.5 volt after performing the procedure you described in step 5, what is your next step?

EGO ALWAYS RICH (Service Code 42)



- Disconnect self-test trigger jumper, or unlatch STAR device push button for the following procedure.
- Verify that all accessories are OFF.
- Do not block throttle open with any device that will actuate the idle tracking switch.

Before proceeding with MCU checks, verify that carburetor choke plate operates freely. If sticking or binding, repair carburetor and repeat RUN Self-Test to confirm service code.

Operation	Result	Action
1. Check circuits 687 and 95 for continuity between MCU and solenoid connectors.	Less than 5 ohms.	Go to Step 2.
	More than 5 ohms.	Repair open circuit. RE-TEST.
2. Check vacuum lines from manifold to fuel control solenoid bottom port, and solenoid middle port to carburetor feedback port, for leaks or blocks.	Lines clear and intact.	Go to Step 3.
	Line(s) blocked or leaking.	Repair vacuum line(s). RE-TEST.
3. Disconnect feedback line from carburetor, and connect vacuum gauge to line. Leave carburetor port open to atmosphere for full-rich carburetion. Start engine and run at 2500 RPM. Observe vacuum gauge after 15 seconds.	Vacuum more than 2.5" Hg (leaning response).	Go to Step 6.
	Vacuum less than 2.5" Hg.	Go to Step 4.
4. Check resistance of fuel control solenoid.	30 to 65 ohms.	Go to Step 5.
	Less than 30 or more than 65 ohms.	Replace solenoid. RE-TEST.
5. Check fuel control solenoid response to known input. Energize solenoid with jumpers from battery positive and ground to solenoid connector, with engine idling. Observe feedback vacuum on gauge connected to feedback line (Step 3).	High vacuum (4-6" Hg) (leaning response).	Replace MCU. RE-TEST.
	Vacuum less than 4" Hg.	Replace Fuel Control Solenoid. RE-TEST.
6. If system responded by leaning in Step 3, check EGO sensor for normal output. Re-connect feedback vacuum line to carburetor feedback port. Disconnect EGO sensor from harness and connect **high-impedance** voltmeter between EGO sensor and ground (set on proper VOLTS range before connecting). Start engine and run at 2000 rpm for one minute to warm up EGO sensor. Turn engine OFF and immediately observe voltmeter.	Less than 0.4 volt.	EGO and MCU system OK. See Group 29, 1981 Shop Manual, for rich carburetor.
	More than 0.4 volt.	Go to Step 7.
7. To rule out exhaust richness as the cause of a high voltage in Step 6, immediately purge the exhaust system as follows: Disconnect ignition coil horseshoe connector and hold throttle wide open while cranking engine for approximately 10 seconds. Check EGO voltage.	Less than 0.4 volt.	EGO and system OK. Check for rich carburetor.
	More than 0.4 volt.	Replace EGO sensor. RE-TEST.

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AUTOMOTIVE COMPUTER UNITS
AUTO MECHANICS SUPPLEMENT

ANSWERS TO ASSIGNMENT SHEET

Assignment Sheet #1

(NOTE: This exercise is intended to help students become familiar with the use of service diagnostic charts associated with automotive computer units, and is not meant to replace manufacturers' publications for actual service work. The answers given below are based on the charts provided with the assignment sheet, which were current at the time of this writing but which may have been revised subsequently. Current manuals may contain answers different from those below.)

A. 1. Visual

2. Answer should include any four of the following

   a. Carburetor

   b. Distributor

   c. Spark plugs

   d. Cooling system

   e. Electrical connections

   f. Vacuum lines

3. Complaints

4. With ECM properly grounded, turn ignition on and carefully observe flash sequence of "check engine" light

5. a. Trouble is intermittent; system is okay at present; clear memory

   b. With engine idling, note dwell; remove large vacuum hose to cause an air leak (but not enough to stall engine)

6. a. Check that pink wire is attached to right-hand terminal of M/C solenoid connector as viewed from harness end; check evaporator canister for being loaded with fuel and the related valves such as purge and bowl vent for leaks which would cause richness; check for fuel in crankcase

   b. Disconnect oxygen sensor; ground connector terminal on lead to ECM

ANSWERS TO ASSIGNMENT SHEET

7. a. With ignition on and engine stopped, remove ground from oxygen sensor harness and check voltage from that terminal to ground with digital voltmeter

   b. Replace ECM

8. a. Faulty oxygen sensor

   b. Check wire from ECM terminal 9 for short to battery positive side; if no short, then ECM is faulty

B. 1. Connect analog voltmeter to test harness; start engine and allow to idle; read the sweep of the voltmeter needle to determine the service code numbers

2. Disconnect self-test trigger or unlatch STAR device push button; verify that all accessories are off; do not block throttle open; verify that carburetor choke plate operates freely; repair carburetor if necessary and repeat RUN Self-Test

3. a. Check vacuum lines from manifold to fuel-control solenoid bottom port, and solenoid middle port to carburetor feedback port, for leaks or blocks

   b. Repair open circuit; retest

4. a. Check resistance of fuel control solenoid.

   b. Check EGO sensor for normal output; reconnect feedback vacuum line to carburetor feedback port; disconnet EGO sensor from harness and connect high-impedance voltmeter between EGO sensor and ground; start engine and run at 2000 rpm for one minute to warm up EGO sensor; turn engine off and immediately observe voltmeter

5. Purge exhaust system; disconnect ignition coil horseshoe connector; hold throttle wide open while cranking engine ten seconds; check EGO voltage

6. Replace EGO sensor; retest

AUTOMOTIVE COMPUTER UNITS
AUTO MECHANICS SUPPLEMENT

JOB SHEET #1 — PERFORM PRELIMINARY CHECKS AND INSPECTIONS ON NON-COMPUTER-RELATED COMPONENTS

I. Tools and equipment

- A. Vehicle
- B. Safety glasses
- C. Digital voltohmmeter
- D. Suitable solvent for testing vacuum leaks
- E. Basic hand-tool set
- F. Hand-operated vacuum pump and instruction booklet
- G. Appropriate pyrometer
- H. Appropriate service manual

II. Procedure

A. Remove air cleaner

(NOTE: To prevent damage to lines or terminals, use care when disconnecting vacuum lines and electrical terminals necessary for removal of the air cleaner.)

B. Perform visual inspection of all vacuum connections

1. Inspect for loose hose connections
2. Inspect for cracked or split hose

C. Inspect diaphragm assemblies with vacuum pump

1. Put on eye protection
2. Remove hose connection at diaphragm to be tested
3. Connect hand vacuum pump to diaphragm
4. Pump to specified activation vacuum
5. Verify proper actuating of unit and retention of vacuum

(NOTE: Be sure to test all vacuum units: heat riser, distributor, cruise control, air conditioner controls.)

6. Remove eye protection

JOB SHEET #1

D. Inspect electrical terminals and connectors
   1. Check for loose connections
   2. Check for corroded connections
   3. Check multiple connectors to ensure that all conductors are making proper contact
   4. Check for broken or frayed wires
   5. Use digital voltohmmeter to perform resistance test on necessary conductors

E. Start engine and let idle at manufacturer's recommended idle speed

F. Check cooling system operation
   1. Check for proper coolant and coolant level
   2. Check for proper operating temperature
   3. Check water pump and clutch fan operation

G. Check engine performance
   1. Check for proper fuel supply
   2. Check for rich fuel condition (flooding)
   3. Check for proper operation of ignition components
      a. Inspect ignition wires (primary and secondary)
      b. Inspect spark plugs
      c. Check distributor function, and inspect components

H. Turn off engine

I. Check cylinder condition
   1. Inspect for proper compression
   2. Inspect for internal oil consumption

J. Repair any faults or defects found

K. Reconnect or reinstall components as required

L. Clean work area; put away tools and equipment

AUTOMOTIVE COMPUTER UNITS
AUTO MECHANICS SUPPLEMENT

JOB SHEET #2 — DETERMINE STORED COMPUTER CODES USING THE "CHECK ENGINE" LIGHT METHOD

I. Tools and equipment

A. Vehicle

B. Grounding wire or device

C. Notebook and pencil

D. Appropriate service manual

II. Procedure

A. Locate proper test terminal connector

(NOTE: Location and grounding procedure varies considerably from one model to another. Consult proper service manual for correct information.)

B. Turn ignition switch to ON position

C. Use grounding wire to ground defined terminals

(NOTE: Some procedures require the ignition switch to be OFF when the terminal is grounded. Follow the procedure exactly as described in service manual.)

D. Observe flashing sequence

(NOTE: Initial code should be one flash—pause—two flashes indicating code 12. Refer to the manufacturer's service manual for specific interpretation.)

E. Observe and record all codes

(NOTE: Each code will flash three times.)

F. Turn off ignition switch

G. Disconnect grounding wire

H. Clean work area; put away tools and equipment

AUTOMOTIVE COMPUTER UNITS
AUTO MECHANICS SUPPLEMENT

JOB SHEET #3 — USE A DIGITAL VOLTOHMMETER

I. Tools and equipment

A. Digital voltohmmeter and instruction booklet

(NOTE: Use only meters with a 10-megohm impedance for testing computerized components.)

B. Circuit containing less than 1 volt

C. Circuit containing variable resistance

D. Appropriate service manual

II. Procedure

A. Test accuracy of voltohmmeter

1. Place meter selectors in TEST position

2. Verify reading on meter with specified reading in instruction booklet

3. If meter is inaccurate, replace with another and repeat test

B. Test circuit containing normal battery voltage

1. Place FUNCTION switch at DC VOLTS indicator

2. Check range of circuit in service manual, and place RANGE switch in proper position

EXAMPLE: Range 1 = 1 to 10 volts
Range 10 = 10 to 100 volts
Range 100 = 100 to 1000 volts
Range 1000 = 1000 to 100,000 volts

(NOTE: If meter is equipped with AUTO position, it will select the proper range automatically. If meter is not equipped with AUTO position, prevent damage to meter by placing range selector on highest scale and reducing to lower scales until satisfactory reading is obtained.)

3. Connect red lead of meter to source of power to be tested; connect black lead to suitable ground; turn on current

JOB SHEET #3

4. Observe reading, and compare to manufacturer's specifications

5. Turn off current, and disconnect meter leads

C. Test circuit of less than 1 volt

1. Place FUNCTION switch at MILLIVOLTS indicator

2. Check range of circuit in service manual, and place RANGE switch in proper position

   EXAMPLE: Range 1 = 0 to 10 millivolts
   Range 10 = 10 to 100 millivolts
   Range 100 = 100 to 1000 millivolts

   (NOTE: If meter is equipped with AUTO position, it will select proper range automatically. If meter is not equipped with AUTO position, prevent damage to meter by placing range selector on highest scale and reducing to lower scales until satisfactory reading is obtained.)

3. Connect red lead of meter to source of power to be tested; connect black lead to suitable ground; turn on current

4. Observe reading, and compare to manufacturer's specifications

5. Turn off current, and disconnect meter leads

D. Test resistance in a circuit or component

1. Turn off current to circuit or component

2. Place FUNCTION switch at proper ohms indicator

   (NOTE: Meter indicators vary; therefore, the indicator may designate OHMS, KILOHMS, or MEGOHMS.)

JOB SHEET #3

3. Check range of circuit or component in service manual, and place RANGE switch in proper position

   EXAMPLES: Function switch in OHMS position:

   Range 1 = 0 to 10 ohms
   Range 10 = 10 to 100 ohms
   Range 100 = 100 to 1000 ohms
   Range 1000 = 1000 to 10,000 ohms

   Function switch in KILOHMS position:

   Range 1 = 1000 to 10,000 ohms
   Range 10 = 10,000 to 100,000 ohms
   Range 100 = 100,000 to 1,000,000 ohms

   Function Switch in MEGOHMS position:

   Range 1 = 1 to 10 megohms
   Range 10 = 10 to 100 megohms
   Range 100 = 100 to 1000 megohms

   (NOTE: If meter is equipped with AUTO position, it will select the proper range automatically. If meter is not equipped with AUTO position, prevent damage to meter by placing selector on highest scale and reducing to lower scales until satisfactory reading is obtained.)

4. Connect either red or black lead of meter to one side of component to be tested; connect other lead to opposite side of component; read resistance value

5. Observe reading, and compare to manufacturer's specifications

6. Disconnect meter leads

E. Deenergize voltohmmeter

F. Clean work area; put away tools and equipment

AUTOMOTIVE COMPUTER UNITS
AUTO MECHANICS SUPPLEMENT

JOB SHEET #4 — PROPERLY SPLICE CONDUCTORS USED IN COMPUTER-CONTROLLED COMPONENTS

I. Tools and equipment

A. Safety glasses

B. Wire stripping and cutting tool

C. Solder gun or iron

D. Rosin-core solder

(NOTE: Do not use acid-core solder.)

E. Splice clips

F. Electrical tape

G. Weather-pack splicing tool

II. Procedure

A. Put on eye protection

B. Disconnect battery cable from battery post

(NOTE: Always disconnect the grounded battery cable first to avoid short circuits. Use proper methods to prevent damage to battery post.)

C. Determine type of conductor to be spliced

(CAUTION: Avoid touching wires and connectors with your bare hands because body chemicals may corrode the connections.)

D. If conductor to be spliced is a twisted/shielded cable, perform the following steps

1. Determine area to be spliced
2. Carefully cut away the outer cable jacket, using care to prevent damage to inner components
3. Cut and unwrap aluminum mylar tape, but do not remove mylar from end attached to outer jacket
4. Cut uninsulated drain wire from one end of section to be spliced

5. Cut inner wires

6. Remove inner wire insulation a sufficient amount to allow installation of splice clips

7. Splice, clip, and solder one wire at a time, using rosin-core solder

8. Wrap each splice individually with sufficient electrical tape

9. Rewrap mylar around newly formed splice area

10. Rewrap uninsulated drain wire around mylar

11. Tape entire section of spliced area

E. If conductor to be spliced is a twisted single lead, perform the following steps

1. Determine area to be spliced

   (NOTE: Do not remove any more wire than is necessary to replace damaged part.)

2. Cut wires and remove insulation a sufficient amount to allow installation of splice clips

3. Install splice clip, and solder to wire with rosin-core solder

4. Wrap each splice with adequate electrical tape to insulate it from other wires

5. Splice all subsequent wires in the same manner

6. Retwist as before

7. Wrap completed splice with sufficient electrical tape to hold wires in place

F. If conductor to be spliced is a weather-pack terminal, perform the following steps

1. Lift locking tab and separate male and female portions of terminal

2. Open secondary lock hinges to allow removal of wires from terminal

3. Using weather-pack splicing tool (J.28742), separate wire connections from terminal

JOB SHEET #4

4. Cut wire immediately behind cable seal
5. Strip 0.2 inches (5mm) of insulation from wire end
6. Place new terminal and cable seal on wire

G. Clean work area; put away tools and equipment

AUTOMOTIVE COMPUTER UNITS
AUTO MECHANICS SUPPLEMENT

TEST

NAME _____ SCORE _____

1. Match to their correct definitions terms associated with automotive computers. Write the correct numbers in the blanks.

_____a.	Electronic device used to store information that can be compared to data on input signals in order to determine the correct output signals	1. Ambient air
_____b.	Read-only memory; portion of computer memory that contains information used in system operation that is not limited to vehicle in which computer is installed	2. Atomization
_____c.	Programmable read-only memory; portion of computer memory that contains identifying characteristics of vehicle	3. Canister purge
_____d.	Random access memory; portion of computer memory used for temporary storage of such information as trouble codes	4. Computer
_____e.	Atmosphere of vehicle's environment	5. Early fuel evaporation
_____f.	System that enhances atomization by using exhaust gases to warm fuel entering the carburetor	6. Light-emitting diode (LED)
_____g.	Process of breaking a liquid into a fine mist	7. PROM
_____h.	Transferal of stored fuel vapors from charcoal filter storage canister to intake manifold	8. RAM
_____i.	Electronic device capable of producing light in the presence of low-level electrical currents	9. ROM

TEST

2. State the purpose of automotive computer systems.

_____

_____

_____

_____

3. List major functions of automotive computer systems.

a. _____

b. _____

c. _____

4. Select from the following list correct functions and operations of major sensor components in an automotive computer system. Write an "X" in the blank before each correct answer.

a. Oxygen sensor

_____1) Compares oxygen content of exhaust gases to that of ambient air

_____2) Sends lower voltage signal to computer if exhaust gases are high in oxygen, indicating that air-fuel mixture is too lean in gasoline

_____3) Adjusts path of exhaust gases to warm carburetor air at higher, cooler elevations

_____4) Sends higher voltage signal to computer if exhaust gases are low in oxygen, indicating that air-fuel mixture is too rich in gasoline

b. Engine coolant temperature sensor

_____1) Sends computer the temperature of engine coolant

_____2) Allows computer to regulate exhaust gas recirculation, air management, and early fuel evaporation

_____3) Allows computer to adjust air-fuel mixture for changes in weather, altitude, and engine load

TEST

c. Pressure sensors

_____1) Allow computer to regulate spark timing

_____2) Send computer changes in manifold pressure and barometric pressure

_____3) Allow computer to adjust air-fuel mixture for changes in weather, altitude, and engine load

d. Throttle position sensor

_____1) Sends computer the position of accelerator pedal and throttle blades

_____2) Allows computer to adjust air-fuel mixture, spark timing, air diversion, and exhaust gas recirculation

_____3) Prevents throttle from getting stuck in full-open position

e. Engine rpm sensor

_____1) Prevents engine overspeed

_____2) Sends computer the crankshaft position and engine rpm by monitoring crankshaft or electronic ignition unit

_____3) Allows computer to regulate spark timing

f. Vehicle speed sensor

_____1) Sends vehicle speed to computer via light-emitting diode

_____2) Monitors number of tire revolutions per minute to signal vehicle speed to computer

_____3) Provides information which, when coordinated with engine rpm and throttle position, allows computer to regulate air-fuel mixture, spark timing, computerized automatic transmission control, shift indicator actuation, and cruise control

g. Knock sensor

_____1) Sends computer frequency of detonation sounds

_____2) Allows computer to regulate spark timing

_____3) Allows computer to reduce air-fuel mixture under heavy engine load

TEST

5. List typical locations of automotive computer system sensor components. Write at least one typical location for each of the sensors given below.

a. Oxygen sensor — _____

b. Engine coolant temperature sensor — _____

c. Pressure sensors — _____

d. Throttle position sensor — _____

e. Crankshaft position sensor — _____

f. Electronic ignition rpm sensor — _____

g. Vehicle speed sensor — _____

h. Knock sensor — _____

6. Match automotive computer system actuator components to their correct functions. Write the correct numbers in the blanks. Answers may be used more than once. Functions are continued on the next page.

_____a. Throttle position is adjusted to maintain engine speed at constant rate despite additional loads placed on engine, such as placing automatic transmission in gear or turning on air conditioner

_____b. Computer sends electrical impulses to solenoids to adjust the metering orifices for proper air-fuel mixture

_____c. Air is directed to exhaust manifold to provide more complete combustion of fuel escaping the combustion chamber

_____d. Injectors open and close on computer command; amount and frequency of opening control fuel for combustion mixture

_____e. Firing time of spark plug is regulated by computer in response to input signals such as those of knock sensor

_____f. Width of orifice opening or the length of time it is open regulates amount of air fed into carburetor

_____g. On computer command, solenoid valve in vacuum line opens and closes exhaust gas recirculation valve to allow exhaust gases into the intake manifold to aid in emission control and to reduce combustion temperatures

1. Air-fuel mixture control, carburetor system
2. Air-fuel mixture control, fuel-injection system
3. Air supply management
4. Engine idle speed
5. Evaporative gas canister purge
6. Exhaust gas recirculation
7. Exhaust manifold heat control
8. Ignition timing control

TEST

_____h. Air is directed to air cleaner to prevent backfire on deceleration and to aid fuel economy

_____i. On computer command, vacuum-controlled solenoids operate to circulate exhaust gases around carburetor base during cold engine operation to improve atomization and to assist with choke warm-up

_____j. On computer command through the use of a solenoid, gas vapors from fuel tank are stored in a charcoal canister and combined with air-fuel mixture in intake manifold

_____k. Diverter valves, controlled by electronic solenoids, direct pumped air to various components to improve combustion efficiency in the engine

_____l. Air is directed into catalytic converter to improve combustion and to help converter reach operating temperature quickly

7. Select from the following list characteristics of a three-stage catalytic converter. Write an "X" in the blank before each correct answer.

_____a. Returns exhaust gas to diverter system for recirculation

_____b. Contains platinum and paladium to neutralize hydrocarbons and carbon monoxide as with earlier-model converters

_____c. Contains rhodium to control oxides of nitrogen (NOx)

_____d. Contains charcoal filters to purge harmful chemicals

8. State preliminary steps in servicing a vehicle with an automotive computer system.

a. _____

b. _____

c. _____

TEST

9. Discuss methods of performing a quick test of the automotive computer system.

   a. Reading "check engine" light

   b. Using special test equipment

   c. Using analog voltmeter

TEST

d. Using vacuum gauges

_____

_____

_____

_____

_____

10. State guidelines for performing a pinpoint test of the automotive computer system.

a. Test procedures — _____

_____

b. Replacing components — _____

_____

c. Beginning pinpoint test when more than one code is displayed — _____

_____

d. Measuring voltage or resistance, or connecting a test light — _____

_____

e. Electrical values of test equipment — _____

_____

f. Comparing electrical values — _____

_____

g. Test probes — _____

_____

h. Isolating components — _____

_____

TEST

i. Make and model of vehicle — _____

_____

j. Erasing codes — _____

_____

k. Repeating quick test — _____

_____

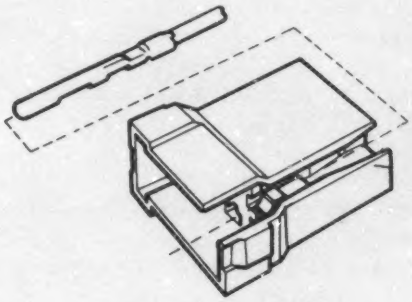
11. Match automotive computer system test equipment to their correct uses. Write the correct numbers in the blanks.

_____a.	Used to test specific system characteristics and functions, often for the equipment of a given manufacturer	1. Digital voltohmmeter (DVOM)
_____b.	Used to check electrical currents and circuit characteristics; specially designed to give precise readouts for low-voltage circuits	2. Dwell meter
_____c.	Used to check for proper ignition spark	3. Hand-operated vacuum pump
_____d.	Used to apply specific vacuums to pressure-sensitive sensors and actuators	4. Jumper leads
_____e.	Used to bypass circuits	5. Spark tester adapter
_____f.	Used to indicate engine revolutions per minute	6. Special test equipment
_____g.	Used to indicate ignition timing	7. Tachometer
_____h.	Used to measure pulse patterns to electrically controlled solenoids	8. Timing light

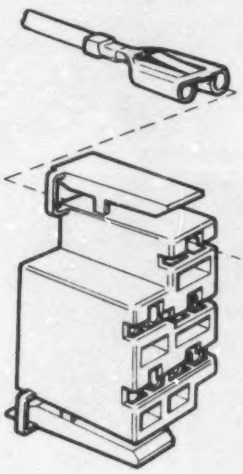
TEST

12. Label the following types of electrical connectors used in automotive computer systems. Write the correct names in the blanks.

a. _____



b. _____



c. _____

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TEST

13. Select from the following list guidelines for splicing conductors in automotive computer systems. Write an "X" in the blank before each correct answer.

    _____a. Follow manufacturer's recommendations as to the kind of splice to make

    _____b. Use wire connectors on each splice

    _____c. Solder all splices

    _____d. Use only double-wrapped wiring

    _____e. Use only conductors with high-temperature insulation

    _____f. Use only the same gauge of wire used by the manufacturer

    _____g. Cut replacement conductors to the same length as the portion of wire replaced

(NOTE: Test questions 14 and 15 list the assignment and job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

14. Use service manual excerpts to determine procedures in response to automotive computer trouble codes.

15. Demonstrate the ability to

    a. Perform preliminary checks and inspections on non-computer-related components.

    b. Determine stored computer codes, using the "check engine" light method.

    c. Use a digital voltohmmeter.

    d. Properly splice conductors used in computer-controlled components.

AUTOMOTIVE COMPUTER UNITS
AUTO MECHANICS SUPPLEMENT

ANSWERS TO TEST

1.

a.	4	d.	8	g.	2
b.	9	e.	1	h.	3
c.	7	f.	5	i.	6

2. To provide more accurate control of fuel-air mixtures, spark timing control, and air supplies to improve engine performance, fuel economy, and emissions control under all driving conditions.

3. a. Input (sensing)
   b. Output (actuation)
   c. Memory (storage)

4.

a.	1, 2, 4	e.	2, 3
b.	1, 2	f.	1, 3
c.	2, 3	g.	1, 2
d.	1, 2		

5. Each answer should contain at least one of the following corresponding locations

   a. Exhaust manifold
   b. Engine water jacket, usually near thermostat housing
   c. Various locations; usually on rear or side walls of engine compartment
   d. Side of throttle body or inside carburetor
   e. Front of timing gear cover
   f. Ignition coil or distributor output signal wire
   g. Rear of speedometer housing or in transmission housing
   h. Intake manifold or engine block

ANSWERS TO TEST

6.	a.	4	d.	2	g.	6	j.	5
	b.	1	e.	8	h.	3	k.	3
	c.	3	f.	1	i.	7	l.	3

7. b, c

8. a. Carefully note driver's complaints and comments

   b. Perform visual inspection and routine checks

   c. Perform quick test if computer-related problem is indicated

9. Discussion should include the following

   a. Reading "check engine" light

      1) "Check engine" light on instrument panel flashes to identify a trouble code number when a specified computer terminal is grounded

         a) One flash followed by a pause represents the number 1, two flashes followed by a pause represents the number 2, and so on

         b) The two-digit trouble code will be repeated

      2) If more than one trouble code is present, each trouble code will be flashed three times, beginning with the lowest number; when all codes have been displayed, the sequence will be repeated

   b. Using special test equipment

      1) Technician follows manufacturer's instructions to ground computer or connect jumper to create a test circuit

      2) Special equipment is then hooked into the test circuit

      3) Test equipment displays a trouble code number on its screen

   c. Using analog voltmeter

      1) Some systems designed to be quick tested with special test equipment may be checked with an analog voltmeter, following manufacturer's instructions

ANSWERS TO TEST

2) Voltmeter is connected to the proper terminals

3) Sweeps of voltmeter needle indicate code number

d. Using vacuum gauges

1) Some codes on some models may be read using vacuum gauges

2) Vacuum gauges are connected to the vacuum lines of thermactor air-control solenoids

3) Sweeps of gauge needles indicate trouble-code numbers

10. a. Follow all test procedures exactly

b. Do not replace any component unless test results indicate that it should be replaced

c. If more than one code is displayed during the quick test, begin the pinpoint test procedure with the first code number given

d. Do not measure voltage or resistance at any component or connect a test light unless the procedure calls for it

e. Make sure that the electrical values of equipment used are within the ranges specified

f. Be sure to make proper contact with test probes.

g. Compare electrical values to those specified by the manufacturer for the exact test conditions being used

h. Do not measure resistance, check continuity, or attempt to energize solenoids or switches without first isolating the component from other components

i. Use only procedure specified for the particular make and model of vehicle as equipped

j. Erase codes in memory if so directed by procedure

k. Repeat quick test to verify that problem has been corrected

11. a. 6 e. 4

b. 1 f. 7

c. 5 g. 8

d. 3 h. 2

ANSWERS TO TEST

12. a. Weather-pack terminal
    b. Pin-type
    c. Blade-type

13. a, c, e, f, g

14. Evaluated to the satisfaction of the instructor

15. Performance skills evaluated to the satisfaction of the instructor